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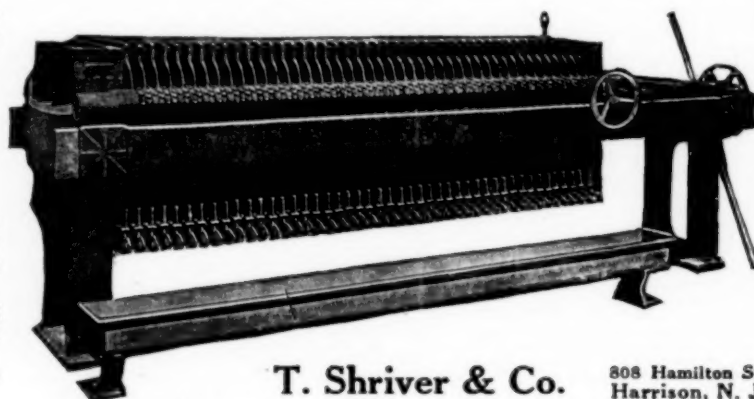
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Supreme Court Declares Hydrogenation Patents Invalid

LAST week the United States Supreme Court handed down a decision of epoch-making importance to the chemical industry in the case of PROCTER & GAMBLE vs. the BERLIN MILLS CO. relating to the hydrogenation of cottonseed and similar oils. In a unanimous opinion in favor of the defendant the court declared invalid claims 1 and 2 of the Burchenal patent for the production of a homogeneous lard-like food product consisting of a partly hydrogenated vegetable oil such as from cottonseed. The case practically turned on the interpretation of the words "homogeneous" and "lard-like."

PROCTER & GAMBLE'S suit against the BERLIN MILLS CO. for alleged infringement of a product made under the Burchenal patent was instituted in 1915 and has attracted widespread attention on account of the prominence of the litigants and the far-reaching importance of the decision when it should be rendered. The plaintiff obtained a favorable decision in the Circuit Court of Appeals, but the defendant succeeded in appealing to the Supreme Court on questions of law. We believe this is one of only seven cases in which the Supreme Court has reviewed an opinion of the Circuit Court unless conflicting opinions had then been rendered.

We hope later to present a more extended review of this important case and will confine immediate comment to a mere indication of one or two salient features. One immediate effect of the decision is to throw open to the public the manufacture of an edible product by the hydrogenation of an oil. Another more widespread result will be from a probable effect on patent law: the recognition of the principle that a product may not be described in terms of a process.

Two Great Americans On Chemical Independence

CHIEF among the founders of our Republic stands ALEXANDER HAMILTON. The governing principle of his policy, of WASHINGTON who supported him, and of the whole Federalist party which followed him, was to establish supreme sovereignty. HAMILTON sought this prime object by threefold means, as is clearly brought out in an excellent appreciation of his life by an admiring Englishman, FREDERICK S. OLIVER. The idea of his financial policy was the welding of the Union, of his foreign policy to confirm independence, and of his commercial policy the development of the estate. Of these, only the last failed of vigorous prosecution and substantial acceptance during his brief lifetime. Indeed the last has been ever at the mercy of logrollers rather than in the hands of statesmen.

HAMILTON'S report to the House of Representatives on manufactures urges that "not only the wealth but

the independence and security of a country appear to be materially connected with the prosperity of manufactures. Every nation, with a view to those great objects, ought to endeavor to possess within itself all the essentials of national supply. These comprise the means of subsistence, habitation, clothing and defense.

"The possession of these is necessary to the perfection of the body politic; to the safety as well as to the welfare of the society. The want of either is the want of an important organ of political life and motion; and in the various crises which await a state it must severely feel the effects of any such deficiency. The extreme embarrassments of the United States during the late war, from an incapacity of supplying themselves, are still matters of keen recollection; a future war might be expected to exemplify the mischiefs and dangers of a situation to which that incapacity is still, in too great a degree, applicable, unless changed by timely and vigorous exertion."

By "the late war" HAMILTON referred to a successful war against Great Britain; many of these phrases bear equal application to conditions existing during and after our recent war against Germany. Indeed, HAMILTON stood on fundamentals and saw wide; he viewed the future as a true prophet. He saw a great continent united by miraculous good fortune into one state, of unknown extent, unexplored except for an eastern fringe. His vision was of one great nation, capable of producing within its own wide borders everything that its citizens would require for safety and for comfort. Distant from its neighbors, it might hope to escape from embroilment in their quarrels; dependent upon them solely for some essential, the wars, disasters and policies of strangers would be a constant menace to its prosperity. It is at the mercy, not only of the malice of its rivals, but of the misfortunes of its friends.

A well-balanced domestic establishment and self-sufficiency in essentials is now and perhaps ever will be a question worthy of serious thought and careful action. Witness the following quotation from the message delivered last week to the short session of Congress by President WILSON—whom even the most rabid critic would not accuse of levity or rashness:

"Permit me to emphasize once more the need for action upon certain matters upon which I dwelt at some length in my message to the second session of the Sixty-sixth Congress: The necessity, for example, of encouraging the manufacture of dyestuffs and related chemicals; the importance of doing everything possible to promote agricultural production along economic lines, to improve agricultural marketing and to make rural life more attractive and healthful."

Can the Republicans follow HAMILTON'S advice and the Democrats follow WILSON'S advice to the extent of adopting a sound policy on chemical independence?

Methods of Making Market Prices

NORMALLY the locomotive engineer regulates the speed of his train from moment to moment according to the nature of the roadway. On the one hand he is not supposed to exceed the safe limit and on the other hand he is expected to keep up to the schedule, while the schedule in turn has been made with a view to getting the patrons of the road to their destinations in the shortest time consistent with other influences. It would certainly be a very crude and inefficient method for the engineer to reduce speed only when he felt some of the wheels leaving the track, or to go as slow as he chose until the passengers held an indignation meeting and formally instructed him to go faster.

The manner in which market prices for many commodities are set is not essentially very different from the alternative manner of operating a railroad train suggested above. Prices are held until an accident occurs, by way of somebody cutting the price, and then producers make a fresh stand upon the reduced price until another accident occurs. For the lower limit, there is a law against unfair or destructive competition whereby in certain circumstances legal process could be invoked to prevent a manufacturer selling below his cost.

A practice of artificial price control among manufacturers is regarded as inherently wrong and against public policy. It is contrary to the common law and is in direct violation of a specific statute, the Sherman "anti-trust" act of 1890, enacted to crystallize the common law, prescribe methods of procedure and fix definite punishment for violation.

In the '90s and in the early years of the present century there were various "pools" and "associations" in the finished steel trade. This was brought out by the Government in the recent suit against the Steel Corporation. The court found, in substance, that the procedure was wrong, and cleared the Steel Corporation chiefly on the ground that its participation ceased in 1904. At the present time there are few associations among manufacturers of the ordinary steel mill products, but there are many associations among consumers of those products. These associations claim to be operating wholly within the law, and that the Federal Trade Commission is cognizant of all their actions. A study of market prices, however, shows that in most cases the manufactured goods sold to the public by members of these associations stand at greater percentages above the pre-war prices than do the rolled steel products which are purchased as raw material from the rolled steel industry.

The spirit of some of these associations seems to be that since they have not the power to hold prices absolutely at all times from going below the level affording a fair profit they should get more "when the going is good" in order to make a suitable average in the long run.

While the steel industry is naturally indisposed to criticize its customers, it does not seem entirely fair that the ultimate consumer should pay a larger profit upon one stage of the manufacture than upon another, when the amount of business done by each successive manufacturer is regulated more or less by the price the ultimate consumer pays.

Commodity prices in general, particularly of manufactured goods, are made by a distinctly hit or miss

process. In the case of hits the seller tries to make them as hard as possible, and for the misses there is nothing but to hope that the hurt will not be serious or permanent. Obviously the old law of competition, if it ever was a safe law, is absolutely ineffective to produce prices at all times fair both to producer and to consumer, because "overhead" has become so large a part of manufacturing cost and in competition a manufacturer does better to lose part of his overhead by selling below total cost than to lose it all by closing his factory. The whole thing is very crude and it is a wonder we get along at all.

Adsorption Phenomena as Applied to Vapor Recovery

IT HAS been only in the past year that research on adsorption of vapors by silica and activated charcoal has given any sign of being productive of an industrial conquest. This is largely due to the introduction of poisonous vapors in offensive warfare with the consequent development of the gas mask as the defensive equipment. In the past the phenomenon of adsorption has received a great amount of speculative treatment and comparatively meager qualitative and quantitative study. The factors have long been recognized in terms about equally complex as adsorption itself, such as capillary-equilibrium between the liquid and vapor phases, which in turn can be resolved first into wetting power of the liquid phase and then to intramolecular forces.

It is observed that when a drop of any liquid is placed on any solid surface, the behavior of the drop is dependent on the resultant of three forces: The surface tension of the liquid in equilibrium with its vapor phase, the contact tension between the liquid and solid, and the surface tension of the solid itself. The magnitude of each of these forces is probably a function of density and intramolecular cohesion, from which we may anticipate the high-surface tension of mercury relative to that of water, and explain the familiar globular form of mercury when in contact with lighter chemically-inert materials. Wetting power is of fundamental importance in capillary adsorption phenomena, for it governs the action of Jurin's Law upon which differences in vapor pressure head depend.

Beginning with this issue, the action of silica gel on single vapors will be described. In the near future, the selective adsorption of the intermediate paraffine series from natural gas by activated charcoal will be taken up, showing that equilibrium tends toward saturation with the higher molecular weight liquids, which expel the lighter ones. Water vapor is at once about the most condensible and greatest vapor expeller that is encountered in adsorption work. Needless to say, where it occurs with the vapor to be adsorbed, the adsorption has to be performed in two stages.

The possibilities of fractionation of mixed vapors by selective adsorption are great, but up to the present they do not seem to have been very extensively investigated. Gases have been cooled below their critical temperature, where the liquid-vapor equilibrium phase replaces the gas state, and there appears to be a possibility that an improvement may be made on the refrigeration method of fractionating such mixtures as air into liquid oxygen and nitrogen gas, with a higher yield than can be economically obtained by the older methods.

Is Chemical Warfare Service Being Stifled?

NOT long ago the Surgeon General of the Army published a report on casualties in the World War which brings out clearly the important part played by gas warfare. In view of the recent history of the Chemical Warfare Service it seems well to summarize them once more.

Out of a total of 258,338 casualties, 70,552, or 27.3 per cent, were caused by gas. Of the 266,112 wounds inflicted upon 224,089 Americans admitted to hospitals, 88,980, or 33.4 per cent, were due to gas. Hand grenades were responsible for 1,158 wounds, pistols 257, bayonets 245, airplane bombs 160 and sabers 14.

Less than 2 per cent of the men suffering from gas admitted to hospitals died, while in the case of the 153,537 suffering from all other classes of wounds admitted to hospitals 12,470, or 8.1 per cent, died. Furthermore, during the years 1918 and 1919, tuberculosis was respectively only 70 and 55 per cent as prevalent among gassed men as among those not gassed.

Study of these data convinces one not only that gas warfare is very effective but that it is also one of the most humane methods of waging war. With these facts in mind, consider the present status of the Chemical Warfare Service. Here are the facts:

The Army reorganization act, approved June 4, 1920, provided for the Chemical Warfare Service in the following language:

Sec. 12a, Chemical Warfare Service. There is hereby created a Chemical Warfare Service. The Chemical Warfare Service shall consist of one chief of the Chemical Warfare Service with the rank of Brigadier General, one hundred officers in grades from Colonel to Second Lieutenant, inclusive, and 1,200 enlisted men. The chief of the Chemical Warfare Service under the authority of the Secretary of War shall be charged with the investigation, development, manufacture or procurement and supply to the Army of all smoke and incendiary materials, all toxic gases, and all gas-defense appliances; the research, design and experimentation connected with chemical warfare and its material; and chemical projectile filling plants and proving grounds; the supervision of the training of the Army in chemical warfare, both offensive and defensive, including the necessary schools of instruction; the organization, equipment, training and operation of special gas troops, and such other duties as the President may from time to time prescribe.

With this authorization, what have the War Department officials done?

Shortly after the passage of the Army reorganization bill, the following paragraph set forth the idea of a special board regarding chemical warfare:

That no troops of the Chemical Warfare Service should be assigned within the Army as combat organizations, but that this Service shall carry on research and development. This is a supply service whose product should be utilized when necessary by combat troops of all arms of the line.

Following the publication of the above mentioned paragraph, tables of organization were issued, in which no mention whatever is made of chemical warfare troops in any military organization for peace or war.

No Chemical Warfare officers have been provided for in any other positions in armies, corps or divisions, notwithstanding they were used on the staff of every commanding general in the World War and were provided for under War Department rules carrying out the provisions of the appropriation act of July 11, 1919, which continued the Chemical Warfare Service during the fiscal year 1920.

This means—if it means anything—that the Army will get no training whatever in chemical warfare.

Apparently to make certain that this training cannot be carried out, a recent decision is that no line officers will be permitted to attend Chemical Warfare Service schools, and that no Chemical Warfare officers will be detailed as instructors in Army service schools or with the National Guard, or in Reserve Officers Training Camps. A tremendous quantity of gas masks and other gas-defense material in the hands of Regular Army divisions in this country and also in the Philippines will soon be without the trained men necessary for their proper care.

Another decision along the same line is not to allow target practice with chemical ammunition other than smoke except at Edgewood Arsenal or Lakehurst, N. J. One of the reasons given for this action was that gas cannot be fired on ordinary target ranges without objection of civilians near by. This in spite of the demonstrated fact that gas can be used with greater safety on such ranges than high explosive.

Is it the idea to teach the Army that gas is too dangerous to train with in time of peace?

Despite the decision that Chemical Warfare Service should primarily carry on research and development, even this activity has been hampered by such acts as the refusal of permission to construct quarters for high-grade civilians at Edgewood Arsenal. This refusal was rendered notwithstanding the Judge Advocate General sustained the opinion of the chief of the Chemical Warfare Service that there was ample law for the use of money now in the hands of the Chemical Warfare Service for that purpose.

While the total appropriation recommended by the War Department for the year 1922 amounts to about \$700,000,000, a little less than \$4,500,000 is for chemical warfare. Is an organization handling a weapon fifty times as effective as hand grenades, pistols, bayonets, sabers and airplane bombs, all combined, to be starved to death?

That these decisions are largely the opinions of Washington War Department officials only is evident from the many requests made for chemical warfare instruction or chemical warfare troops by commanding generals of divisions, corps areas, departmental areas or service schools outside of Washington. For instance the commanding general of Camp Benning, Ga., has tried for six months to have a company of chemical warfare troops sent there. The chief of infantry has strongly indorsed such request. Needless to say also, the chief of the Chemical Warfare Service has done everything he could to get them sent there, but every request has met with constant refusal.

We repeat the question at the head: "In the light of these facts, can one conclude that the Chemical Warfare Service is being stifled?"

Minerals Separation's Application Again Denied

UPON another page we print a brief abstract of the opinion of the United States Circuit Court of Appeals, which not only fully sustains the District Court in its denial of a petition to find the Miami Copper Co. in contempt for continuing its flotation operations but would seem to add force to what we interpreted as a rebuke from the District Court because of its necessity of speaking twice to be heard.

Readers' Views and Comments

Electric Furnace Refractories

To the Editor of Chemical & Metallurgical Engineering

SIR:—In a recent article in your journal entitled "Electric Furnace Refractories," by A. F. Greaves-Walker,¹ certain statements are made with regard to magnesite which need correction.

The author mentions the two general types of naturally appearing magnesite—namely, crystalline and amorphous, and then proceeds to state that the latter is entirely unsuited for the manufacture of refractories. This statement has been shown, both by laboratory research and actual practice, to be incorrect, although it has occurred from time to time in the literature and has been generally accepted as true up to very recent times.

The truth of this statement was given some apparent substantiation by the general failure of the California amorphous magnesite to yield a satisfactory refractory magnesite and by the great success, as a refractory, of the dead-burned magnesite shipped from Chewelah, Wash., by the Northwest Magnesite Co. But the Northwest Magnesite Co. was the first in the United States to build and operate a plant which produced a true dead-burned magnesite. No such plants have ever existed in California on an extensive scale, and no true dead-burned magnesite has ever been produced in California, except on a small scale. However, this small production has been recognized for some years as a very high-grade refractory material, and it served a valuable purpose during the war as a lining for furnaces producing carbon-free ferro-alloys. Washington magnesite, if calcined by the usual California method, would be worthless as a refractory material. The production of a high-grade refractory magnesite is largely a matter of process and apparatus, and provided the original analysis of the rock is within certain prescribed limits it makes no difference whether it be in crystalline or in the so-called amorphous state, if the proper procedure be followed which is necessary for the production of dead-burned magnesite.

These statements, which are the result of practice, of course proceed from certain underlying facts regarding the nature of magnesite. There is no real distinction between crystalline and so-called amorphous magnesite, except in the size and development of the crystals. (The amorphous is in reality a cryptocrystalline magnesite.) Crystalline magnesite is usually less pure than the cryptocrystalline, and particularly it usually contains more iron; but there are deposits of cryptocrystalline magnesite in California which contain more iron than the Washington crystalline magnesite, and also some which contain less iron and more lime and silica.

Both crystalline and cryptocrystalline magnesite, when properly calcined at 750 to 800 deg. C., yield amorphous magnesia entirely free from CO₂ gas and of a greater or less degree of purity, according to the constituents of the original rock. Amorphous magnesia, owing to its low specific gravity and its tendency to

shrink at high temperatures, is worthless as a refractory material. If its temperature is raised to 1,550 deg. C. and if 5 to 6 per cent Fe₂O₃ be present and intimately mixed with it, amorphous magnesia is completely transformed to a crystal known as periclase and the resulting product is dense, hard and sintered, and is known as dead-burned magnesite.

These facts disclose that dead-burned magnesite is produced by a heat treatment of CO₂-free amorphous magnesia, whereby periclase is formed, and it makes no difference whence the amorphous magnesia came. Furthermore, the production of dead-burned magnesite is only incidentally connected with the calcining of magnesite. All of the CO₂ can be driven from magnesite without producing a single per cent of periclase, and on the other hand periclase can be produced from amorphous magnesia which never had been in the form of the carbonate. Periclase was never completely formed in California magnesite, and the magnesite was therefore never completely dead burned because the calcined magnesite was never heated as high as 1,550 deg. C., but if it did happen to be heated to this temperature in the process of manufacture, there was not sufficient iron present to initiate the crystallization. The great bulk of California magnesite, therefore, which was shipped in the early days of the industry, was not thoroughly dead burned. It was considered so at that time, however, because dead burning and calcining were confused and it was thought that all that was necessary to accomplish the dead burning of magnesite was to completely drive off the CO₂ gas.

The presence of iron oxide is necessary in making dead-burned magnesite because it catalyzes the transformation of amorphous magnesia to periclase. If iron is not present, this transformation requires a higher temperature than is practical in ordinary commercial furnaces using oil or coal as fuel. Microscopic examinations have demonstrated that iron oxide added to the rock under proper conditions is exactly equivalent in its action to the iron which occurs naturally in the rock.

Consideration of these facts entirely refutes the old and oft-repeated claim which Mr. Walker has again repeated, that Austrian magnesite is a material in a class by itself. No one disputes the fact that it is an excellent refractory material, but we now know both from practice and laboratory research that we are producing the same material in America, and the best proof of this statement is that American metallurgical industries, including those employing electric furnaces, have been operating without hindrance in so far as refractories are concerned for over two years, using almost entirely American magnesite. Inquiries which have been made from time to time of those operating open-hearth furnaces and electric furnaces establish the fact that American magnesite is giving the highest satisfaction and is considered the equivalent, in every particular, of Austrian magnesite.

Northwest Magnesite Co.,
San Francisco, Cal.

ROBERT D. PIKE,
Consulting Engineer.

¹Nov. 10, 1920, vol. 23, p. 933.

Action of Steam and Gases on Yields of Ammonia From Carbonization of Oil Shales and Coal

Discussion of the Various Factors and Physicochemical Laws Affecting the Ammonia Equilibrium—
Synthetic Action of Steam and Hydrogen—Removing Action of
Inert Gases From Decomposition Zone

BY ARTHUR J. FRANKS

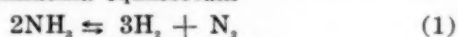
THE importance of nitrogen to the industrial, agricultural and military progress of nations has stimulated prolific research in methods of production, and especially conservation of this resource. In certain localities the principal source of nitrogen lies in the byproduct ammonium compounds obtained from the carbonization of coal and oil shales; and activities in the direction of byproduct recovery are continually expanding in the great countries of the world.

The steaming of retorts has accelerated this advance toward the conservation of the ammonia yield, and steaming practice has been under investigation for nearly a century with the view of magnifying its usefulness. Yet when one refers to the literature for the reactions involved, or the *modus operandi* of the steaming process, only very meager data, generally from plant practice (and sometimes of questionable accuracy), are found, together with the admission of our ignorance of the principles involved, or, what is less satisfactory, dubious hypotheses which are unable to withstand the light of our present knowledge.

PRINCIPAL FACTORS INVOLVED IN AMMONIA EQUILIBRIUM

As ammonia decomposes at temperatures below those of the ordinary coal or oil shale retort, how are we to explain the yield which is nevertheless produced, as practice shows? Ignorance of the laws involved has given rise to many controversies. Some have even gone so far as to state that "there is something unsound in your theory, which is not a safe guide to follow." It is generally not the theory which is at fault, but its misapplication to conditions under which the theory cannot be expected to hold. It will be the purpose of this paper to consider these various physical conditions, in connection with the effect of steam and inert gases on the ammonia yield, and to interpret the phenomena that attend in the light of our physicochemical laws.

It is first necessary to consider all the pertinent facts involved in the ammonia equilibrium¹



as well as the general laws that govern:

At or above 780 deg. C., and at atmospheric pressure, the equilibrium is displaced completely to the right (in an iron tube and in the absence of catalysts)—that is, the decomposition is complete.²

The dissociation is endothermic, hence the equilibrium is shifted toward the right as the temperature rises.

The decomposition proceeds with an increase in volume and is therefore favored by the reduction of pressure.

The introduction of inert gases at constant volume has no effect on the equilibrium.

Dilution with inert gases attended with an increase in volume displaces the equilibrium to the right, or increases the dissociation.

Increasing the concentrations (and hence the partial pressures) of either the N_2 or H_2 , or decreasing that of the NH_3 , will shift the equilibrium to the left.

The rate of the reaction to the left is proportional to the product of the concentrations of the decomposition products, with a constant thermodynamic environment.

Catalysts have a very pronounced action on the temperatures of decomposition and especially upon the reaction rate, which is very slow.

DECOMPOSITION TEMPERATURE

According to the experiments of Ramsay and Young pure ammonia is completely decomposed at 780 deg. under the conditions given. But it must be remembered that these conditions do not obtain in practice during the retorting of oil shale or coal, for equilibrium is not attained, and that temperature is the controlling factor in determining the degree of dissociation *only when complete equilibrium is reached*. Unless the system is in equilibrium we have no means of predicting what the dissociation constant will be, but the dissociation will, of course, be greatly decreased.

Other factors, not considered in the observations of Ramsay and Young, enter during the carbonization process to further complicate the thermodynamic environment. Hence, for our present purpose, the results of those experiments are of little value, and become less and less applicable as the number of variables in the system increases.

DISSOCIATION IS ENDOTHERMIC

From the endothermicity of the reaction and the principle of Le Chatelier it is evident that heat aids the dissociation of ammonia into its elements, and that the higher the temperature the greater is the decomposition. The magnitude of this dissociation by heat is, of course, greatest at equilibrium, but it proceeds at all times to a greater or less degree, depending upon the nature and number of other

TABLE I. EFFECT OF TEMPERATURE ON NH_3 FORMATION

T. Abs. C.	t. deg. C.	X	X _c
973	700	0.000174	0.000183
1,073	800	0.000088	0.000089
1,203	930	0.000043	0.000042
1,273	1,000	0.000032	0.000029

variables in the system. Table I demonstrates the effect of temperature rise on the amount of ammonia found in an equilibrium mixture of 75 per cent hydrogen and 25 per cent nitrogen at one atmosphere pressure, the values being taken from the observations of Jost.³

¹Jellinek, "Physikalische Chemie der homogenen und heterogenen Gasreaktionen," p. 682.

²Ramsay and Young, *J. Chem. Soc.*, vol. 45, pp. 88-93; 1884.

³*Z. anorg. Chem.*, vol. 57, p. 425 (1908).

In this table X is the volume of NH_3 per unit volume of mixture as observed, and X_c the calculated results from Nernst's form of the reaction isochor.*

The influence of the presence of other gases in the mixture together with the lack of equilibrium would effect a tremendous difference in the above figures, but the actual results under such changed conditions could hardly be predicted except within the limits of pure speculation. This is clear from results of experience in gas manufacture. If the dissociation proceeded at the rate given for the temperatures in Table I no ammonia would ever be found in the gas, as it would all be decomposed at 800 to 900 deg., the temperature which practice demonstrates to be the most favorable⁵ for the greatest ammonia yield.⁶ The explanation for such apparently contrary phenomena can be found only in the absence of equilibrium and the presence of gases other than ammonia, especially hydrogen. The manner in which these conditions produce the above-mentioned results will be evident from the discussion in another part of this paper.

EFFECT OF PRESSURE AND VOLUME

Since the dissociation proceeds with a volume increase, pressure will act to reverse the reaction and shift the equilibrium to the left according to the Le Chatelier principle. Conversely, a reduced pressure favors the disintegration of the ammonia molecule. Now this action of pressure is not affected by the presence of inert gases (so long as the partial pressure of the ammonia in the gas mixture is unaltered), and tends to manifest itself whether the system is in equilibrium or not. Unfortunately, however, carbonization is generally carried out at pressures but slightly greater than atmospheric; hence we can look to no aid from this source to explain away our anomaly, and the pressure factor may be hereinafter neglected.

EFFECT OF INERT GASES AT CONSTANT VOLUME

It is at once apparent from Dalton's law that dilution of the reaction mixture with indifferent gases at *constant volume* would have no effect upon the dissociation, since the partial pressures of the reacting components would not be so changed. But the introduction of steam and inert gases (such as are evolved during the carbonization) cannot be considered as taking place without a volume change, as this is accomplished at practically *constant pressure*, and the gas volume is thereby *increased*. This gives rise to the condition considered under the next head.

EFFECT OF INERT GASES WITH INCREASE IN VOLUME

From the principle mentioned above it would be logically supposed that dilution attended with an increase in volume would increase the dissociation. This is always the case where the decomposition is accompanied by a volume increase or where the products of the dissociation occupy a greater volume than the undissociated substance, since the dilution results in a lowering of the partial pressures of the components concerned in the reaction.

The mechanism of the diluting phenomenon will be clearer from a study of the following example. Assume an ammonia equilibrium within a constant thermo-

dynamic environment, the temperature being that at which the gases are present in the molal concentrations given in equation 1 for ease in calculation, and the pressure being six atmospheres. According to the mass law there is a definite ratio at all times between the amounts of each component of this mixture, from which is obtained the dissociation constant K , or from equation 1,

$$\frac{[N_2][H_2]^3}{[NH_3]^2} = K; \quad (2)$$

where $[]$ signify the volume concentration of the component in question. Since the concentrations of the constituents are proportional to their respective partial pressures, or to the number of mols present, equation 2 may also be written:

$$\frac{P_{N_2}(P_{H_2})^3}{(P_{NH_3})^2} = K_p = \frac{1(3)^3}{(2)^2} = 6.75. \quad (3)$$

Now assume a dilution to occur without a change in pressure, so that the volume is now two times the original. The partial pressures of the ammonia, hydrogen and nitrogen are consequently reduced to one-half their former values and the equation becomes:

$$\frac{0.5(1.5)^3}{(1)^2 X} = \frac{1.6875}{X} = 6.75. \quad (4)$$

Since K_p is a constant the value of X becomes $\frac{1}{4}$, which means that the equilibrium will shift until the concentration (and hence the partial pressure) of the ammonia becomes one-fourth of its original value. Thus the dissociation would have been increased fourfold by a dilution with an equal volume of an inert gas.

In spite of the above facts and the deductions therefrom it is known from practice that the yield of ammonia is increased by dilution instead of decreased, as would be expected. This is simply accounted for by the fact that part of the diluting gas is hydrogen, which is not inert, and that the mass law is valid only at equilibrium; and since the conditions that exist are far from such a state the law does not pretend to hold. However, the *tendency* toward dissociation of course exists, but is more than completely overcome by the relatively high velocity of the gases through the reaction zone, which, due to the slow rate of reaction to the right (in equation 1), causes the ammonia molecules to be removed before the predatory actions of temperature and dilution have had an opportunity to accomplish much of their evil work, and by the presence of much hydrogen, which operates against the decomposition.

SHIFTING THE EQUILIBRIUM

Obviously, this is again an application of the mass law. If the concentrations of the nitrogen or hydrogen exceed those required by the equation, and the presence of an excess of one or both of these elements can be accounted for in ordinary carbonization practice, then we will have another part of our explanation for the conservation of the ammonia yield. The hydrogen has an especially potent action on the shifting of the equilibrium to the left, for, from equation 3, the amount of ammonia varies directly as the *cube* of the hydrogen partial pressure or concentration, assuming a constant thermodynamic environment. For example, increasing the partial pressure (at constant temperature) of the hydrogen from three to six in equation 3 causes a shift in the equilibrium until the ammonia concentra-

*Z. Elektrochem. (1910), p. 100.

⁵Lewes, Carbonization of Coal, p. 259.

⁶In an ordinary horizontal retort and without steam.

tion becomes *eight times* the original value, as the calculations demonstrate:

$$K_p = 6.75 = \frac{(1)(6)^3}{X(2)^2} = \frac{54}{X}; \text{ or } X = 8. \quad (5)$$

Following the same reasoning, it is seen that the nitrogen will have less effect on the equilibrium, the ammonia varying directly with the nitrogen concentration. Here again it must be remembered that while the above phenomena occur to the extent shown only at equilibrium, the tendency is nevertheless in the direction indicated.

In order to apply the results of these observations to the retorting of oil shale or coal, the source of the nitrogen and hydrogen and their relative approximate concentrations must be determined. This must be accomplished for four different sets of conditions:

- A. Retorting at low temperatures without steam.
- B. Retorting at low temperatures with steam.
- C. Retorting at high temperatures without steam.
- D. Retorting at high temperatures with steam.

RETORTING AT LOW TEMPERATURES WITHOUT STEAM

Research on carbonization⁷ has established the fact that at low temperatures (not above 500 deg. C.) ammonia is a primary decomposition product and is formed directly from the nitrogen compounds existing in the material distilled. Such being the case, the influence of an excess of ammonia decomposition products would result in the tendency to prevent the equilibrium from going toward the right, since the combination of hydrogen with nitrogen is very slow and the reaction to the left would therefore be practically *nil* under the conditions that obtain.

The ammonia in the gases from the low temperature carbonization (at about 500 deg. C.) of oil shales or coal seldom exceeds 5 per cent by volume.⁸ The hydrogen in the coal gas, on the other hand, will vary between 25 and 30 per cent,⁹ and in the oil-shale gases it will be between 20 and 25 per cent.¹⁰ The percentage of nitrogen is quite low in good gas, and as it has relatively little effect on the decomposition it need hardly be considered. The predominance of hydrogen over ammonia at these temperatures is therefore apparent, as well as the result.

RETORTING AT LOW TEMPERATURES WITH STEAM

At the low temperatures here considered the dissociation of steam into its elements is almost zero, as Table II¹¹ shows.

Also, the amount of hydrogen produced from the ac-

TABLE II. DISSOCIATION OF WATER VAPOR AT ATMOSPHERIC PRESSURE

Temperature, Deg. Abs.	Percentage Dissociation
1,000	0.00003
1,500	0.022
2,000	0.59
2,500	3.98

tion of steam on carbon is relatively small up to 500 deg. C.¹² Hence the steam can be considered here to act mainly as a mechanical agent which serves to prevent the decomposition of the ammonia by removing it from the zone of reaction and thus forestalling equilibrium. The hydrogen formed during the carbonization

has, of course, the same action as in retorting at low temperatures without steam, but to a lesser degree, due to the lowering of its partial pressure by the steam. Any inert gas would have practically the same effect as the steam under these conditions.

RETORTING AT HIGH TEMPERATURES WITHOUT STEAM

The same general considerations governing retorting at low temperatures without steam hold at high temperatures of carbonization (about 800 to 900 deg. C.), except that the percentage of hydrogen in the gases is much greater, being usually from 45 to 55 per cent.¹³ Hence its protective action will be much increased. But on the other hand, the destructive tendencies of the elevated temperature will also be more pronounced; yet its influence is mitigated by the slow velocity of reaction (equation 1) to the right. It is evident that the resultant of these two opposing forces could not be predicted with any precision because it is dependent, under the given conditions of temperature and pressure, mainly upon the velocity of the gases through the zone of reaction. So the problem would have to be worked out empirically for any given set of conditions.

In connection with the action of hydrogen on the yield of ammonia from coal at high temperatures, the work of Tervet¹⁴ will be of interest. His experiments showed that a stream of hydrogen, introduced at red heat into a mass of coal from which the rich hydrocarbon gases had just been distilled, caused the formation of ammonia in considerable quantity. These experiments were carried out with charges of 100 g. of coal in a 4-in. iron tube, the temperatures running up to almost 1,000 deg. C. The higher the temperature and the greater the velocity of the hydrogen through the tube the greater was the amount of ammonia produced.

Tervet's explanation of the action of the hydrogen is that "the nitrogen existing in coke can be liberated in the form of ammonia, it being only necessary to bring the compound into a state of strain by subjecting it to the superior affinity which exists between the combined nitrogen in the coke and the free hydrogen at a particular temperature and in a predominating atmosphere, which shall prevent it from subsequent decomposition." Tervet made experiments with other gases also, and found that nitrogen, methane and carbon dioxide had no action, and carbon monoxide very little, but that coke which had been submitted for hours to the action of these gases, which had failed to wash out any trace of ammonia, directly a stream of hydrogen was passed through it yielded ammonia in abundance.

If any ammonia had been produced during the carbonization at these high temperatures as a *primary* decomposition product, then some of it should have been found in all the wash gases, at least at high velocities through the tube. Its absence permits only one conclusion—that the ammonia was synthesized from the nitrogen in the coke and the hydrogen, the presence of the enormous excess of the latter preventing the reversal of the ammonia reaction toward the right and increasing the velocity of the reaction to the left. The mechanism of this phenomenon will be elucidated later.

RETORTING AT HIGH TEMPERATURES WITH STEAM

The use of steam during high-temperature carbonization introduces a number of complications, since it can no longer be assumed to be inert. Under the condi-

⁷Lewes, Carbonization of Coal, p. 254.

⁸Ibid., p. 255.

⁹Ibid., p. 255.

¹⁰From analyses by the author.

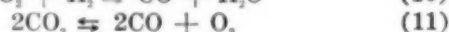
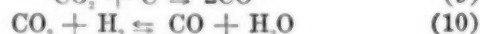
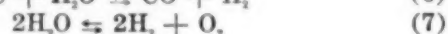
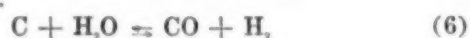
¹¹Nernst, Theoretische Chemie, 6 Aufl., p. 681.

¹²Luggin, J. Gasbel. u. Wasserversorg., vol. 41, p. 713 (1898).

¹³Lewes, Carbonization of Coal, p. 163.

¹⁴J. Soc. Chem. Ind., vol. 2, p. 445 (1883).

tions that obtain we have to deal with the system C, H₂O, CO, CO₂, H₂, and hydrocarbon vapors, in addition to the system represented by the ammonia equilibrium. The reactions and possible side reactions involved are quite numerous:



The main reaction is represented by equation 6, but the others also occur to a greater or less extent, depending upon the thermodynamic environment. The oxygen is not included in the system, because it is always in combination with either the hydrogen or carbon; and the extent to which it combines with one or the other depends also entirely upon the thermodynamic environment.

The reason for introducing the above equations into our considerations is that they must all be studied in order to ascertain the amount of free hydrogen which may be expected to be present in the system under a given set of conditions, since this seems to be the primary factor in determining the progress of the ammonia decomposition and association reactions. As the hydrocarbon vapors are practically all evolved during the first part of the carbonization when the temperature of the material being distilled is low, they may be dropped from the system at this point. The carbon dioxide and excess of undecomposed steam have no action, and the carbon monoxide practically none, on the formation of ammonia, but act merely as diluents and mechanical agents for removing the ammonia molecules from the zone of reaction before decomposition can make material progress. Only the hydrogen is left then for consideration here.

At high temperatures hydrogen has the effect noted in retorting at high temperatures without steam, but to a much greater degree due to the increased amount present, and also the synthetic action studied by Tervet.¹⁸ An idea of the amount of hydrogen formed by the action of steam on coke at various temperatures may be obtained from Table III.¹⁹

The amounts of the various gases are expressed in volume per cents, and the velocity, *V*, in liters per second.

It is evident from the table that at high temperatures the steam is almost entirely decomposed by the carbon

be mainly in the direction of depressing the decomposition of the ammonia. As the temperature of the mass of coal or oil shale rises, more and more hydrogen is produced from the steam, and the Tervet reaction begins, it being more and more prominent as the amount of hydrogen and the temperature increase. Here again the high velocity of the gases through the retort and the great excess of hydrogen produced from the use of steam, together with the slow rate of decomposition of ammonia, account for its integrity on the one hand and its partial synthesis on the other.

RATE OF REACTION PROPORTIONAL TO PRODUCT OF DECOMPOSITION PRODUCTS

Experiments show that in gaseous systems within a constant thermodynamic environment the rate of a chemical reaction is proportional to the product of the concentrations of the reacting molecular species, each concentration being raised to a power equal to the number of molecules of the corresponding molecular species entering into the reaction, as indicated by the equation expressing the reaction as it actually occurs. This is Guldberg and Waage's law¹⁷ of chemical mass action as applied to rates of reaction. Where the reaction is reversible, as is the case with ammonia, then the resultant reaction rate at any time is the algebraic difference between the two opposing rates, the sign being considered positive when this difference is in the direction of combination, and negative when toward dissociation. These facts may be represented very clearly by the use of the calculus in the following equations:

$$-\frac{d[\text{NH}_3]}{dt} = K[\text{NH}_3]^2 \quad (12)$$

$$-\frac{d[\text{H}_2]}{dt} = -\frac{d[\text{N}_2]}{dt} = k[\text{H}_2]^3[\text{N}_2] \quad (13)$$

$$-\frac{d[\text{NH}_3]}{dt} = -\frac{d[\text{NH}_3]}{dt} + \frac{d[\text{H}_2]}{dt} = K[\text{NH}_3]^2 - k[\text{H}_2]^3[\text{N}_2] \quad (14)$$

Here the square brackets represent the concentrations at the time *t* of the molecular species in question, expressed as equivalents per liter. The derivative of any concentration with respect to the time represents, of course, the rate of change of that particular concentration, and as the concentration progressively diminishes during a decomposition the sign of the differential is negative. However, as soon as the rate of combination exceeds that of decomposition, the sign changes to positive. This is evident from equation 14, which expresses the resultant rate of reaction.

A study of this equation also renders obvious the fact that an increase in the concentration of the hydrogen should cause a tremendous increase in the reaction rate (and this in the positive direction) since it is proportional to the cube of the hydrogen concentration, and that the rate of the decomposition¹⁸ (or the reaction in the negative direction) will be comparatively very small because the concentration of the ammonia in the gases is exceedingly low, being less than 2 and usually not over 1 per cent by volume in carbonization at high temperatures with a liberal use of steam. Thus the net result, or the resultant positive rate of reaction, should be relatively high. These considerations furnish the most plausible explanation for the Tervet reaction and the production of additional ammonia by the use

TABLE III. CARBON-WATER REACTION AT VARIOUS TEMPERATURES

Temp., Deg. C.	H ₂	CO	CO ₂	H ₂ O	V
674	8.4	0.6	3.8	87.1	0.9
758	22.3	2.7	9.2	65.8	1.8
838	28.7	6.0	11.3	54.1	3.7
858	32.8	8.0	12.1	47.2	3.3
861	36.5	11.0	13.3	39.2	5.3
954	44.4	32.7	5.7	17.2	6.3
1,010	47.3	48.2	1.5	3.0	6.2
1,060	48.8	46.3	1.3	3.7	9.8
1,125	50.7	48.3	0.6	0.3	11.3

according to equation 6, and that the side reactions occur only to a negligible degree. The high percentages of hydrogen are also to be noted. During the earlier part of the carbonization hydrogen is also produced in considerable amounts, and its action at that stage would

¹⁸Loc. cit.

¹⁹Luggin, *J. Gasbel. u. Wasserversorg.*, vol. 41, p. 713 (1898).

¹⁷Nernst, *Theoretical Chemistry*, or any text on physical chemistry.

¹⁸See p. 1,149.

of steam during carbonization, when taken in connection with the high velocities of the gases through the zone of reaction and the natural slow rate of decomposition of the ammonia molecule.

CATALYTIC ACTION

Mention has already been made of the fact that the decomposition of ammonia into its elements is very slow, as is often the case with endothermic reactions. This has been shown experimentally by Perman and Atkinson,²⁰ and by Bodenstein and Kranendieck,²¹ who have investigated the rate of isothermal dissociation at different temperatures and found that the rate of reaction is greatly affected by catalysts, which both accelerate the decomposition and lower the temperature of dissociation. It is the opinion of Bodenstein and Kranendieck that the reaction goes on entirely in the surface of the containing vessel, and not in the gaseous phase. The conclusions of Ramsay and Young²¹ point in the same direction.

Table IV shows Bodenstein and Kranendieck's²² determinations of the rate of decomposition of ammonia in a quartz tube at 780 and 880 deg. C. and at different initial pressures, by the manometric method. The

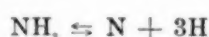
TABLE IV. RATE OF DECOMPOSITION OF AMMONIA

Temperature, 780 Deg.				Temperature, 880 Deg.			
$P_1 = 145.6$		$P_1 = 235.6$		$P_1 = 225.5$		$P_1 = 614.6$	
Time	$(N_2 + 3H_2)$	dx/dt	$(N_2 + 3H_2)$	dx/dt	$(N_2 + 3H_2)$	dx/dt	$(N_2 + 3H_2)$
0	00.0	0.0	00.0	0.0	00.0	0.0	00.0
5	46.4	4.65	48.8	4.95	60.0	6.0	100.0
10	69.6	2.30	81.0	3.20	115.1	5.4	197.9
15	84.4	1.48	102.2	2.12	196.7	4.0	283.0
20	94.3	1.00	119.9	1.78	352.8	7.0	464.3
25	103.1	0.84	133.4	1.36	540.5	3.9	721.0
30	111.0	0.61	144.7	1.14	681.4	2.1	746.0
40	121.0	0.44	164.8	1.00	721.0	2.0	769.4
50	129.6	0.36	180.7	0.80	769.4	1.2	
60	136.7	0.34	204.4	0.60			
70	143.4	0.34	212.1	0.39			
80	157.1	0.25	226.4	0.36			
100			241.4	0.36			
120							
125					386.8	0.40	

greater rates obtained with the higher initial ammonia concentrations are noticeable at the lower, and very marked at the higher temperature, as would be predicted from the mass law.

The time expressed in minutes and the amount of $N_2 + 3H_2$ formed is expressed in mm. P_1 is the initial pressure in mm. of the ammonia at the beginning of the experiment, and dx/dt represents the rate of change in the ammonia concentration, or the rate of decomposition.

Analogous results were obtained by Perman and Atkinson,²⁰ who studied the dissociation in a porcelain vessel at temperatures from 677 to 1,111 deg. C. They showed, however, that a thin deposit of platinum black on the surface of the vessel caused a marked increase in the rate of decomposition, as well as a lowering in the temperature of decomposition. Iron had also a pronounced effect. In the absence of catalysts and at high temperature the reaction is shown to proceed as one of the first order, or



The union of the atoms to form molecules is probably so quick that it is negligible when compared with the rate

of decomposition of the ammonia molecule. This is similar to the decomposition of phosphine,²³ which has recently been shown to be a monomolecular reaction. The experiments at lower temperatures (about 800 deg.) as well as Bodenstein and Kranendieck's²¹ work at these temperatures furnish definite evidence that the reaction is of neither the first nor the second order, since the values for the dissociation constant fluctuate too widely from that of a true constant. But this is to be expected when it is recalled that the walls of the retaining vessel exert a catalytic action on the dissociation rate. The curves of Perman and Atkinson²⁰ illustrate this point beautifully.

Bodenstein and Kranendieck²² investigated also the rate of decomposition of ammonia in the presence of an almost equal concentration of its dissociation products. The results of this work indicate that the concentration of the ammonia in the mixture is of greater importance than that of the hydrogen and nitrogen, the decomposition rate being faster with higher ammonia concentrations, as would be predicted from the mass law. The hydrogen and nitrogen do not have the effect which would be expected. However, the deviations from the theory are quite satisfactorily explained in their paper on the basis of catalytic action, and need not be considered here.

In substantiation of the deductions already drawn from the works of a number of capable investigators, and the applications made thereof, the conclusions from the experiments of Ramsay and Young²¹ on the decomposition of ammonia may be briefly reviewed. They point out that this decomposition begins at about 500 deg. C., but is very small at that temperature, and that the magnitude of the dissociation depends not so much upon the degree of heat as it does upon the rate of gas flow through the reaction zone and the nature and extent of surface with which the gases come in contact during their passage through this zone. These experimental facts, formerly opaque and obtained at a time when much of our present theory and knowledge was lacking, can now be applied to carbonization practice through the medium of our more recent knowledge of gas kinetics. The demonstration of this harmony between theory and practice is ever gratifying.

SLOW DISSOCIATION RATE

Application of the principles discussed herein to the explanation of the action of steam and inert gases on the ammonia yield during carbonization leads to the general deductions that at low temperatures the steam and gases act both to prevent dissociation of the NH_3 molecules by their presence and to remove them mechanically before material decomposition occurs. At high temperatures steam has also a synthetic action due to the production of large quantities of nascent hydrogen through its reaction with the hot coke and the union with some of the nitrogen contained therein to form new ammonia. The low percentage of this substance and the high per cent of hydrogen in the gases operate to quicken the rate of reaction to the left (equation 1) and, what is of more importance, to depress the rate of decomposition, which has been shown to be very slow. Although the depressing effect of the

²⁰Proc. Roy. Soc. London, vol. 74, p. 110 (1904).

²¹Nernst-Festschrift, p. 99 (1912).

²²J. Chem. Soc., vol. 45, p. 88 (1884).

²³Nernst-Festschrift, p. 113.

²⁴Loc. cit.

²⁵M. Trautz and D. S. Bhandarkar, Z. anorg. Chem., vol. 106, p. 95 (1919).

²⁶Loc. cit.

²⁷Proc. Roy. Soc., vol. 74, p. 115.

²⁸Loc. cit.

²⁹Loc. cit.

hydrogen on the dissociation does not appear to be as great in the few cited cases as would be expected from theoretical considerations, its influence must be felt, since it is present in the gas mixture in amounts twenty-five to fifty times greater than that of ammonia. However, the very slow dissociation rate to the right (equation 1) is the real key to our exposition.

In concluding what may sometimes appear as unnecessarily detailed as well as irrelevant considerations, the author takes the further liberty of emphasizing a few general facts. In dealing with systems that contain such hosts of variables as do the present ones it must be remembered that any knowledge, however remote, which sheds even a tiny ray of light upon the subject is to be accepted gratefully and applied judiciously. There is no doubt that precise results could never be obtained for such cases as those discussed herein except by purely empirical experimentation with a given set of rigid conditions; nor does this paper make any attempt in this direction. The purpose is rather to assemble our pertinent knowledge with the view of arriving at certain definite generalizations and applying these to the elucidation and orientation of what before was to many a confusion of diverse and vacuous facts. If even a partial fulfillment of this purpose obtains, then the author will indeed be satisfied.

Production of Yacca Gum in South Australia

Prior to the war the gathering and shipping abroad of South Australian yacca gum was an important industry on Kangaroo Island, just off the south coast of South Australia, reports Consul H. P. Starrett, of Adelaide. As Germany was the largest user of this product, the industry was suspended during the first years of the war, and not until use had been found for it in the United Kingdom and in America during the latter part of 1916 did the production revive. In 1919 more than 10,000 tons was gathered, and as the Australian consumption is small the greater part of the output was shipped to Great Britain and to the United States. It is believed that further experiments in the use of this valuable product may develop a larger scope for its utilization and thus encourage the expansion of the industry at Kangaroo Island.

USES—CHEMICAL REACTIONS

Before the war nearly two-thirds of the Australian output was bought by German firms. Local dealers have never been able to discover what use the Germans put it to, but it is believed that it was used in the manufacture of furniture polish and lacquer for metal ware. It should not be overlooked, however, that the product contains a high percentage of picric acid on nitration and it is not unlikely that it was also used by the Germans in the manufacture of explosives—a use to which it was put by the Allies in 1917 and 1918.

The gum from the species *Xanthorrhoea hastilis* is, of course, one of the oldest known sources of picric acid, yielding about 15 per cent by treating the gum with strong nitric acid. The gum has also been used in the manufacture of dyes. To quote a technical report on the subject: "The high yield of picric acid on nitration and of paraoxybenzoic on alkaline fusion indicates a chemical constitution for the resin of an oxygenated benzene derivative, and among such derivatives are numerous fine chemicals in daily use—viz., photographic

SUMMARY

The various factors and general laws that affect the ammonia equilibrium have been pointed out and each discussed in detail in connection with the experiments and conclusions of previous investigators.

The information so obtained has been applied to the exposition of the action of steam and inert gases on the yield of ammonia from the carbonization of oil shales and coal.

The integrity of the ammonia molecule at high temperatures and under the other conditions that obtain in retorting is explained by its very slow rate of dissociation, and the remoteness from equilibrium, a condition which is brought about by the presence of steam and inert gases, these removing the ammonia before decomposition can make any marked headway.

The steam is shown to have a synthetic action at high temperatures, and the *modus operandi* of the synthesis of ammonia from the nitrogen contained in the coke is elucidated.

The author takes this opportunity to express his profound gratitude to Dr. S. C. Lind for his many valuable suggestions and criticisms, and for his kindly aid which was always so gladly given.

Colorado School of Mines,
Golden, Col.

developers and material used in the preparation of synthetic dyestuffs. The resin is also said to be of considerable importance in the manufacture of linoleum."

Experiments have shown that the gum is soluble in alcohol but insoluble in turpentine, linseed oil, benzene, molten paraffine, and hydrocarbon solvents generally. It dissolves readily in aqueous solutions of caustic alkalis to deep red solutions and, on the addition of acids, is reprecipitated more or less completely as a flocculent dull yellow precipitate. The gum is partly soluble in cold strong sulphuric acid to a deep red solution; on dilution of the sulphuric acid solution and cleaning, the brownish red solid separates. When filtered and freed from the sulphuric acid, this solid dissolves in water and is reprecipitated from its aqueous solution by the addition of a little sulphuric acid.

DESTINATIONS OF EXPORTS

The following table shows the amounts and values of the exports of yacca gum from the State of South Australia for the calendar year 1913 and the fiscal years (ended March 31) 1917-18 and 1918-19. The values have been reduced to American currency at the rate of \$4 to the pound sterling:

Destination	1913		1917-18		1918-19	
	Hundred-weight	Value	Hundred-weight	Value	Hundred-weight	Value
United Kingdom.....	5,234	\$5,536	5,603	\$12,648	7,022	\$9,836
United States.....	600	600	2,004	2,404	651	848
Germany.....	14,100	12,484				
France.....	1,212	1,540				
Belgium.....	392	360				
Netherlands.....	105	88				
Total.....	21,643	\$20,608	7,607	\$15,052	7,673	\$10,684

The exports of yacca gum to the United States as declared at the consular office during the calendar years 1917, 1918 and 1919 were as follows: 1917, 2,979 hundredweight, valued at \$4,977; 1918, none; and 1919, 7,600 hundredweight, valued at \$37,970.

The market price in the city for yacca gum varies from \$36 to \$44 per long ton. Freight, insurance and handling charges amount to about \$48 per long ton.

Adsorption by Silica Gel*—I

Basic Facts and Observations on Adsorption of Vapors by Silica Gel—Partial Vapor Pressure and Liquid Volume Relationships in Capillary Equilibriums at Different Temperatures—Data on Sulphur Dioxide

By E. B. MILLER

THE adsorption of vapors by certain porous bodies such as charcoal, kieselguhr, etc., has long been a matter of common knowledge. It was soon found that the retention by such adsorbents was not related to the chemical composition of the substance adsorbed, but was in some way connected with the ease of condensation of the adsorbed vapor. A rough parallelism was noted between adsorption and the boiling point of the vapor when condensed to a liquid.

Much of the uncertainty and inaccuracy of the early adsorption work was due to the difficulty of preparing adsorbents of constant properties. When it was found that adsorbents could be prepared from certain colloidal solutions in an easily reproducible manner it then became possible to study the phenomenon of adsorption with some degree of certainty. Furthermore, when it was found that these latter adsorbents possessed the power of adsorption equal if not superior to that exhibited by adsorbent charcoal the experimental study was made comparatively simple.

Silica gel, prepared from the coagulation of a colloidal solution of silicic acid, is such an adsorbent, and in many respects is an ideal substance for the study of adsorption. It is easily made under conditions that may be reproduced with considerable exactness. It is prepared from inexpensive raw materials, water glass, and either hydrochloric or sulphuric acid. Chemically, it is most inert and is therefore stable in air even at high temperatures.

The adsorption of a number of vapors by silica gel has been studied at different temperatures.

From the results of such experiments it has been possible to discover the factors that are of importance in determining the extent of adsorption.

ADSORPTION DEPENDENT ON VAPOR PRESSURE

It was found that vapors of liquids of a high boiling point were more strongly adsorbed than vapors from a liquid of a low boiling point. Furthermore, adsorption decreased with increasing temperatures. Also, the greater the partial pressure of vapor being adsorbed the greater was the extent of the adsorption. All these facts suggested the idea of condensation of the vapor in the adsorbent. Pursuing this thought, we selected as a measure of the ease of condensation the ratio of the pressure of the vapor in equilibrium with the adsorbent to the vapor pressure of the liquid at the temperature of adsorption. This ratio is herein designated as the "corresponding" pressure. It was soon established that vapors of high corresponding pressure were more strongly adsorbed than those of lower corresponding pressure. The relationship, while qualitatively true, did not correctly represent the phenomena quantitatively.

It was then noted that when the corresponding pressure equaled unity—i.e., when adsorption was measured at the vapor pressure of the liquid, the volumes of the adsorbed liquid were in all cases the same. In other words, it is advantageous, inasmuch as it tends toward simplicity, to express adsorption in terms of volume of adsorbed liquid rather than in weight. The volume of adsorbed liquid was obtained by dividing the weight of the substance adsorbed by the density of the liquid at the temperature of adsorption.

This simple relationship was found to be true only in the case of measurements carried out at a corresponding pressure of unity. At lower corresponding pressures the volume of the adsorbed liquid was not the same at the same corresponding pressure. This discrepancy was attributed to the fact that the condensed liquid under corresponding pressures less than unity had a density smaller than the normal density. Furthermore, the greater the compressibility of the liquid the greater was the deviation of the density of the liquid in the adsorbent from the normal density. By taking these additional facts into consideration all of our experimental observations were quantitatively brought into complete harmony. We are therefore in position to say that the factors influencing adsorption are the corresponding pressure, and the compressibility of the adsorbed liquid.

We have yet to consider the properties of the adsorbent that determine its activity. Inasmuch as the chemical nature of the latter apparently is of no moment, we are forced again to a consideration of a physical property. All adsorbents are porous, and the internal volume is large and composed of exceedingly fine pores. Furthermore, capillarity tells us that a liquid in a small tube possesses a lower vapor pressure than the normal vapor pressure. In other words, it is easier to condense a vapor into a small capillary than on to a level surface. We have therefore in the above all that is necessary to characterize an adsorbent. It must possess as large an internal volume as possible and this volume must be made up of spaces of minimum dimension.

PARTIAL PRESSURE

When we consider silica gel as an adsorbent for the vapor of a liquid at a given temperature, we have to take into account two things: (1) the partial pressure or concentration of the vapor to be adsorbed; and (2) its vapor pressure at the temperature of adsorption. Denoting the partial pressure by P and the vapor pressure by P_0 , we may define the "corresponding

pressure" by the quotient $\frac{P}{P_0}$. It has been found experimentally that the amount of a particular vapor adsorbed increases with increasing value of the ratio $\frac{P}{P_0}$. Now for

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a given partial pressure, the value of $\frac{P}{P_0}$ increases with decreasing temperature, and for a given temperature, the ratio $\frac{P}{P_0}$ increases with the increase of partial pressure. Hence in practice, we have better adsorption the lower the temperature and the greater the concentration of the vapor to be adsorbed. Maximum adsorption, at a given temperature, will take place when $\frac{P}{P_0}$ has its maximum value, which is unity.

Let us consider a few examples. We may adsorb water vapor at 30 deg. C. from air saturated at 30 deg. C. Under these conditions, $P = P_0 = 30$ mm., and the gel will take up an amount of water corresponding to 25 to 27 per cent of its own weight.

If we consider a similar mixture of sulphur dioxide and air at 30 deg. C.—that is, a mixture in which the partial pressure of sulphur dioxide is 30 mm. (which corresponds to about 4 per cent by volume)—the ratio $\frac{P}{P_0}$ is much smaller than in the case of water, due to the greater vapor pressure of sulphur dioxide. From such a mixture the gel takes up sulphur dioxide to about 6 per cent of its own weight.

If we use a mixture of carbon dioxide and air of the same concentration as above, the value of $\frac{P}{P_0}$ at 30 deg. C. is quite small and only a slight amount of carbon dioxide will be adsorbed.

TEMPERATURE AND CONCENTRATION EFFECT

From a mixture of sulphur dioxide and air containing 4 per cent by volume of sulphur dioxide (partial pressure about 30 mm.), the gel takes up 3, 6, 8.2 and 11.1 per cent sulphur dioxide by weight at 40, 30, 20 and 10 deg. C., respectively. The effect of concentration may be illustrated by the following: Working at 30 deg. C., the gel takes up 2.3, 6, 7.1 and 8 per cent

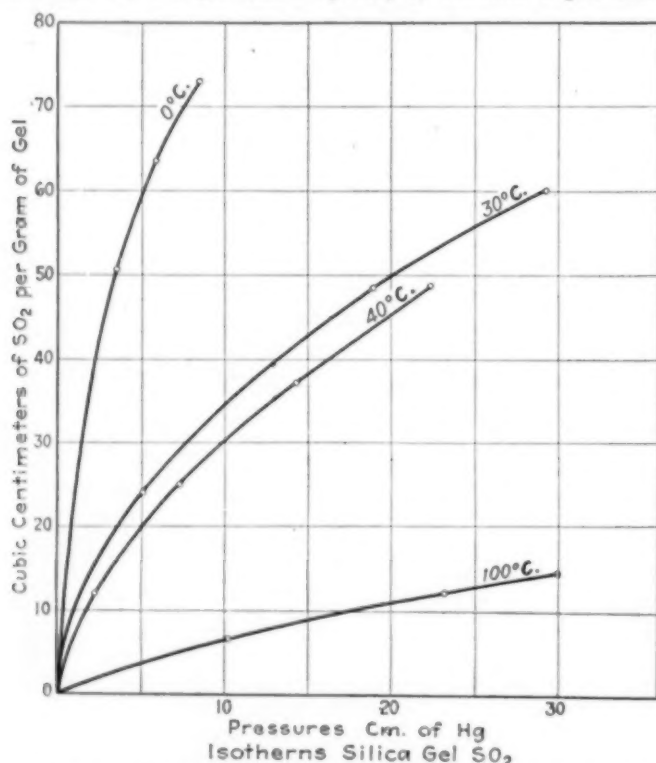


FIG. 1. ADSORPTION OF SO_2 IN C.C. AT 0, 30, 40 AND 100 DEG. C.

by weight of sulphur dioxide from mixtures containing 1, 4, 6 and 8 per cent, respectively.

Inasmuch as the adsorptive power of silica gel does not depend upon any specific chemical action, but rather upon the physical properties of the vapor to be adsorbed, it may be used successfully at ordinary temperatures and atmospheric pressure to remove from air the vapors of any liquid mixed with air in any proportions, provided the liquid boils, under atmospheric pressure, above -10 deg. C. We must exclude, of course, any vapor which like hydrofluoric acid attacks silica.

From what has been said it will be obvious that lower boiling liquids may also be adsorbed, but it would hardly be practicable to do so efficiently at the ordinary temperature. The so-called permanent gases may be adsorbed at temperatures below their critical points, in their vapor phases, and it is quite likely that such a

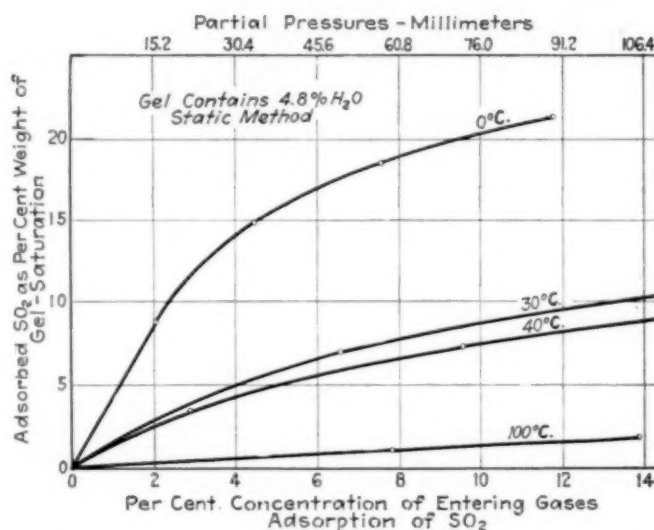


FIG. 2. ADSORPTION OF SO_2 IN PER CENT OF GEL WEIGHT

problem as the fractionation of liquid air into oxygen and nitrogen would be made easier by the use of silica gel.

From what was said above in the discussion of corresponding pressure the obvious procedure to follow in order to recover the adsorbed material consists in two steps: (1) raise the temperature, and (2) decrease the partial pressure of the vapor over the gel by evacuation or by displacement with air, steam or other gas or vapor.

Thus adsorbed water may be driven out by air at 115 deg. C., more rapidly at 125 deg. C., and still more rapidly at 150 deg. C. High boiling liquids may be adsorbed without difficulty, but require a correspondingly high temperature for recovery from the gel. Silica gel is almost ideally adapted to the adsorption and recovery of the vapors of liquids boiling between 30 and 150 deg. C. in that it takes up large quantities of these vapors at room temperature and gives them up readily at slightly elevated temperatures—that is, from 100 to 200 deg. C. This classification includes most of the important solvents, such as ether, acetone, methyl and ethyl alcohol, benzene, gasoline, methyl and ethyl acetates, and many others.

We shall see also that it offers a satisfactory means for drying air and for the recovery and concentration of the vapors of more volatile liquids such as sulphur dioxide.

A more detailed discussion of the theory of adsorp-

tion as applied to sulphur dioxide may be found in an article by John McGavack, Jr., and W. A. Patrick, in the *Journal of the American Chemical Society*, vol. 42, p. 946 (May, 1920).

LABORATORY RESULTS

Experimental results obtained on the laboratory scale, on the adsorption and recovery of sulphur dioxide, boiling point at -8 deg. C.; ether, $+35$ deg. C.; acetone, $+56$ deg. C.; benzene, $+80$ deg. C.; water, $+100$ deg. C., and gasoline will be discussed in the order named.

SULPHUR DIOXIDE

The adsorption of sulphur dioxide by silica gel has been thoroughly studied both by the static and dynamic methods.

The static method consists in placing a convenient amount of the gel in a small apparatus which is then exhausted to the highest vacuum obtainable. To insure complete removal of air the vessel is heated to 300 deg. C., and this temperature maintained, with the pump in continuous operation, for six hours, or until no more air can be pumped off. The pump used is the Gaeda high vacuum mercury pump. The vessel containing gel is then placed in a thermostat and a known amount of sulphur dioxide introduced. After the system has come to equilibrium, which requires not over fifteen minutes, the pressure is observed and the quantity of sulphur dioxide adsorbed determined. Fig. 1 gives the results of four series of results obtained in this way at 0 , 30 , 40 , and 100 deg. C. respectively. Fig 2 gives a recalculation of these results in which the ordinates express the adsorbed sulphur dioxide as per cent of gel weight instead of cubic centimeters per gram of gel.

The dynamic method consists in placing a convenient quantity of granular gel, usually 10 g., in a glass tube of 1 to 2 sq.cm. in section bent in the form of a U for convenience of immersion in the thermostat, and passing through the gel at a given temperature a definite mixture of sulphur dioxide and air. The air and sulphur dioxide are metered separately through carefully calibrated flowmeters similar to those used by the Chemical Warfare Service, passing first into a

particular mixture and temperature. The results of a series of experiments in which the concentration of the sulphur dioxide-air mixture varied from 0.5 to 8 per cent by volume and the temperature varied from 10 to 40 deg. C. are given in Fig. 3. A comparison of Figs. 2 and 3 shows substantial agreement between the results given by the two methods. In other words, the presence of gas has, for practical purposes, a negligible effect upon the adsorption of sulphur dioxide vapor by silica gel.

The details of one set of experiments (at 20 deg. C.) are shown in Fig. 4, in which the results are shown as percentage efficiencies against time. The ordinates here express the sulphur dioxide adsorbed as percentage of the total being admitted to the gel. With regard to these experiments we desire to make the following comments.

The rate of flow of gas through the gel was 40 c.c. per minute per gram of gel, or 0.65 cu.ft. per minute per pound of gel. This means that the time of contact

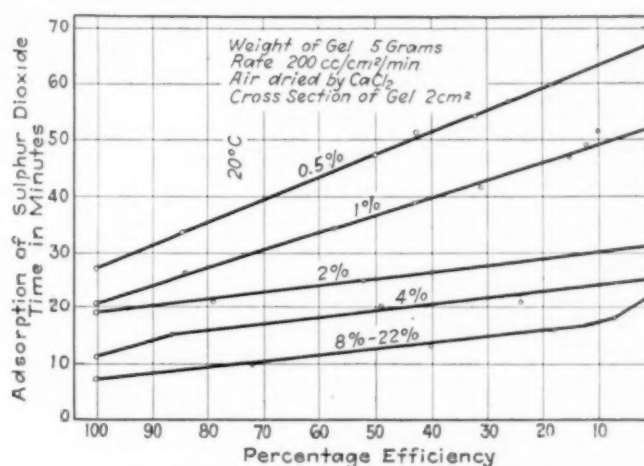


FIG. 4. PERCENTAGE ADSORPTION EFFICIENCY

of gas with gel was approximately 0.8 second. Notwithstanding this short interval allowed for adsorption, in each run no detectable trace of sulphur dioxide passed the gel for a considerable period. In other words, we had 100 per cent adsorption for a certain period, depending upon the concentration, after which the efficiency curve falls off abruptly to zero adsorption. We denote the time at which the first trace of sulphur dioxide comes through as the "break point." An examination of the curves at 20 deg. C. will show that for all concentrations the gel was not less than 57 per cent saturated at the break point.

As already stated the rate used in these experiments was 40 c.c. per minute per gram of gel, which allows about 0.8 second for contact. If necessary, higher rates may be employed.

Fig. 5 shows that for a 0.75 per cent vapor the slopes of the efficiency curves are very nearly the same for rates ranging from 25 to 75 c.c. per minute per gram of gel. A practical rate for adsorption in general is 50 c.c. per minute per gram of gel, which is approximately 0.8 cu.ft. per minute per pound of gel. This allows about 0.6 second for contact.

The gel granules used in all these experiments varied in size between 8 and 14 mesh. The size of the gel particles has a very practical bearing in two respects. In the first place, it is obvious that the larger the particles the greater the time necessary for the adsorbed material to penetrate to the interior and that, for ad-

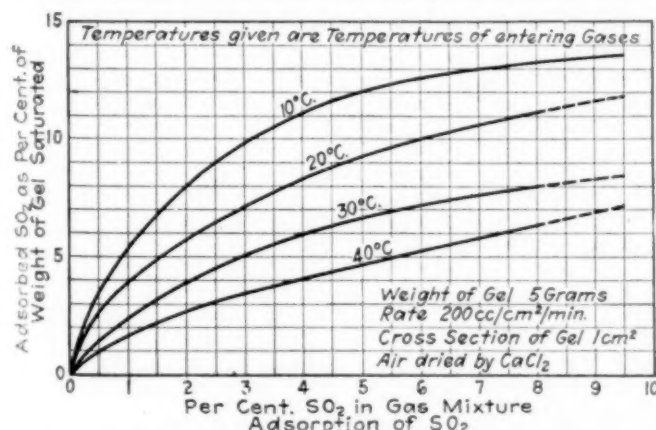


FIG. 3. ADSORPTION IN PER CENT OF SATURATED GEL WEIGHT

mixing chamber and thence over the gel. Under these conditions the gel adsorbs the sulphur dioxide completely for a certain period. At the end of this period a trace of gas begins to come through, the percentage of sulphur dioxide in the exit gas increasing rapidly, becoming finally equal to that of the entering gas. This corresponds to the point of saturation for this

sorption purposes, it would be desirable to reduce the size of particles as much as practicable. The final saturation value would not be changed, but the break point would occur later and the latter part of the efficiency curve would be steeper, which is advantageous. Clearly, however, for the type of absorber being considered, there is a practical limit to the size of particles that may be employed, for it is obvious that the smaller the size the greater will be the pressure required to force the gases through the gel bed. Resistance to gas flow will be discussed further under "Experimental Plant Results" in Part III.

RECOVERY

With respect to the recovery of adsorbed material, silica gel has marked advantages over other adsorbents. By reference to the curves already given it will be seen that the gel takes up very little sulphur dioxide at 100 deg. C., even with high concentration. These curves indicate the obvious procedure to follow in using the gel. Adsorption should take place at as low a temperature as is practical, and for recovery the whole should be heated to 100 deg. C. or more. The exact procedure to be used depends upon the concentration of sulphur dioxide desired.

Let us assume, for example, that we have a gas which is 4 per cent sulphur dioxide by volume, and that we

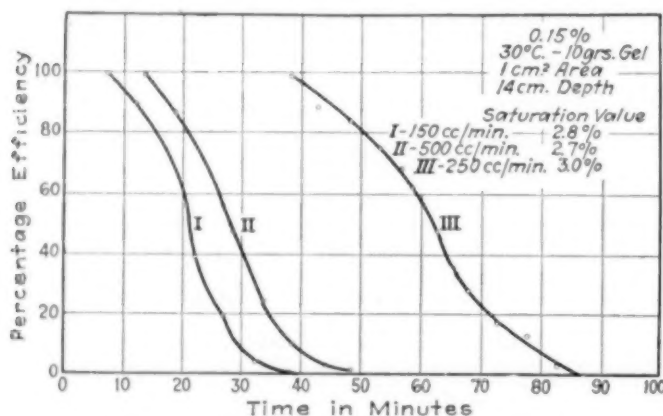


FIG. 5. COMPARISON OF EFFICIENCIES

wish to concentrate this to 8 per cent for use in the lead chamber process for making sulphuric acid. And let us assume an adsorption temperature of 30 deg. C. We see from the curves that using a 4 per cent vapor and working at this temperature, the gel will take up 6 per cent of its own weight of sulphur dioxide. After adsorption the temperature is raised to 100 deg. C. and the sulphur dioxide swept out by means of an air stream, the volume of air being so regulated to give the desired concentration. We may, if it is so desired, obtain in this way a much higher concentration than 8 per cent. It is possible to go from 4 to 30 per cent in one step by simple air displacement at atmospheric pressure. It is easily possible in this way to concentrate as lean a gas as 1 per cent to 8 per cent in one step.

If the object is to obtain high percentage, as for example in making liquid sulphur dioxide, air would not be used, but the adsorbed SO_2 liberated at 100 deg. C. or above, by evacuation. By proper regulation of temperature, pressure and volume of air admitted any desired concentration up to practically 100 per cent may be obtained.

Parts II and III will be published in subsequent issues.

Diatomaceous Earth

BY NORRIS GOODWIN

THE last five or six years have witnessed a great awakening among the industrial minds of this country to the value of the so-called industrial minerals. Chief among these in variety of uses if not on actual volume of production is diatomaceous earth, or kieselguhr. The history of this material may be traced back to the sixth century A.D., when its use in the manufacture of lightweight fireproof brick and building material was certainly understood. Its use, however, passed into a long period of darkness, along with so many other useful arts known to the ancients, that have been brought back to the service of mankind in only comparatively recent times.

The immediate cause for the introduction of the material to modern trade seems to have been the rapid growth of the use of high-pressure steam for power and heat during the early part of the nineteenth century. The conveying of high-pressure steam to any distance from its point of origin made the use of some form of insulation essential, and the credit for adapting kieselguhr to this purpose appears to belong to the Germans, who about 1860 began to mine it near Luneberg, Hanover, and to market it as a steam pipe covering. So valuable a material could not be ignored in other lines, however, and its uses have gradually spread until today over one hundred and fifty separate and distinct uses for it could be enumerated.

ORIGIN OF DIATOMACEOUS EARTH

The material as it is quarried looks very much like chalk, and in fact it may supplant that material in the manufacture of blackboard crayons. Strictly speaking, it is composed of the siliceous skeletons of countless millions of diatomacea or infusoria of both fresh water and marine origin. So small are these skeletons that one cubic inch of the earth may contain fifty or seventy-five million skeletons. Microscopists have classified many thousand varieties of these dainty fossils; in fact they will remain one of the most fascinating fields of microscopic research.

Much interest attaches to large deposits of diatomaceous material, particularly in the West, by reason of its proximity to the known oil fields. In fact there seems little question that it is the primary source of the asphaltic petroleum of these regions. The theory is that by a process of decomposition under the influence of heat and pressure the bodies that originally inhabited these skeletons have been converted into the hydrocarbons comprising petroleum. So porous are the beds left behind that they would offer but little resistance to the displacement, by water or gravity, of the oil to the nearby strata. Strength is given to these conclusions by the presence in German kieselguhr of as high as 40 per cent of organic matter much resembling petroleum.

From a commercial standpoint the value of the material depends on the nature of its silica content and on the shape of the individual skeletons.

Just what condition the silica, that makes up from 75 to 95 per cent of the earth, is in, is not as well known as might be desired. Possibly it is a colloidal hydrated silica with proportions of the opaline variety which vary with the source, age and previous treatment of the particular earth in question. The main impurity, which

may run from 0 to 15 per cent, is clay, besides which lime, magnesia, iron oxides and organic matter may occur in minor proportions.

Geographically it is distributed in nearly every country of the world, but probably the largest single deposit of pure material is that at Lompoc, Santa Barbara County, Cal., where there are at present several companies engaged in actual production. Here the material occurs in thick beds, varying in color from pale brown to pure white and in texture from a soft clay-like mass to a hard flint-like diatomaceous shale. Gem opals are found at times in the bed of the mass. The mining is simple, open quarry methods being used. After quarrying, the material is allowed to stand in the air for some time to dry, after which it is pulverized and settled out of a current of air which grades it according to size.

USES OF DIATOMACEOUS EARTH

Without question, the two largest uses at the present time are for heat insulation and for filtration, both of which depend more on the physical than the chemical composition of the material. As a thermal insulator it is without peer, for, besides its ability to withstand a high heat and a corrosive atmosphere, its billions of inclosed air cells offer an almost perfect barrier to the passage of heat. Bonded with lime it is marketed in the form of brick and tile, while in the powder form it is packed loose in specially constructed furnace walls, or is mixed with small quantities of bonding materials for direct application as a plaster. At times small quantities of effervescing materials have been added with the bonding agent to increase its porosity.

As a filtrant it is used directly as a filter body and as an added filtering agent to maintain the filter cake in a porous condition. It also has some considerable decolorizing powers and has been applied either alone or mixed with fuller's earth to the filtering of vegetable and mineral oils, sugar solutions, and in fact wherever a mild decolorizing agent combined with an efficient filtering body is desired. To what particular property of the earth this decolorizing action is due is a disputed question. In the light of recent researches into the properties of silica gels, it might be thought that the answer was close at hand, yet many authorities with years of practical experience behind them stoutly maintain that the only criterion is the nature of the individual diatoms as shown by a careful microscopic examination. At least it appears that the small honeycomb-shaped diatoms have a greater decolorizing power than the long rod-shaped varieties, yet this may also be explained on the basis of the surface exposed.

The same qualities which go to make diatomaceous earth invaluable as a heat insulator and filtering agent also make it of value in many other ways. Mixed with lime or gypsum it has found use both as a building plaster and a fertilizer. L. Kern has found that when it is saturated with waste sulphite liquors it makes a good fertilizer (U. S. Pats. 1,144,905, 1,145,370). Peterson-Hviid has found it suited to the manufacture of casein glue in that when added to the freshly precipitated curd it renders uniform the drying and oxidation and makes the resulting products more easily soluble in alkali (British Pat. 1,016 of 1914 and Danish Pat. 18,160 of 1913). As a basis for plastic compositions its use is obvious. In the hydrogenation of vegetable oils some rigid yet porous support for the catalyzer is often a great advantage, and here again diatomaceous earth is more suited than any (U. S. Pat. 1,167,915). German

Patent 291,792 of 1913 refers to the use of vanadic acid precipitated on kieselguhr in the manufacture of sulphuric acid by the contact process.

Since a considerable portion of the silica in diatomaceous earth is soluble in alkali it has been used to some extent in the manufacture of sodium silicate in place of the more difficultly soluble quartz. Only the purest grades free from iron are adapted to this purpose, however. The same fact is responsible for its use in the manufacture of ultramarine.

Many of the early dynamites were compounded with kieselguhr as an inert absorbent, and a list of the commercial products depending on it as a filler would include rubber, phonograph records, sealing wax, match heads, soaps—in fact any product where a light, cheap, inert filling agent is desired. Even the sacred realms of death itself have been invaded, for we have the word of O. Gangloff (D. R. P. 291,526 of 1914) that mixed with naphthalene and paraffine it makes a most serviceable covering for coffins.

The bibliography given herewith, although not as exhaustive as could be desired, mentions most of the important articles which have dealt with this interesting material in the last few decades.

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Defects in Steel Originating in the Ingot

Microscopic Appearance of Breaks and Inclusions of Non-Metals in Steel, Which Defects Originate During Pouring or Solidification—Various Deoxidizers and Their End Products Are Listed and Briefly Discussed

By AUSTIN B. WILSON

DEFFECTS may be defined as those substances and conditions in the metal which make for failure during normal fabrication or in service. Different classifications might be proposed in a systematic study, but in the present article the writer intends to deal with those defects in steel, as they appear under microscopic examination, which originate in the pouring and solidification of a steel ingot.

OVERHEATING MOLTEN STEEL

Under this heading those defects caused by overheating the molten metal would naturally come first. Aside from the danger of change in chemical composition due to loss through volatilization, oxidation or undesired reaction with the furnace lining or slag to which overheating may give rise, the ever-present danger of the finished steel containing oxidation products is greatly augmented. Under favorable conditions it will lead to the presence of oxides of silicon, manganese or iron in the finished steel, possibly in such amounts as to affect seriously the physical properties of the steel.

Absorption of gases is another of the ill effects which are promoted by the overheating of the molten metal. Of the gases absorbed during overheating, oxygen, hydrogen and nitrogen are by far the most important and the most commonly encountered. These gases may be present in the finished steel in any or all of the following forms: Mechanically entrapped either in blowholes or between the crystal boundaries; in solid solution in the steel; or as compounds such as oxides, nitrides, etc., either in suspension or in solution in the steel. It is noteworthy that these gases are more

soluble the higher the temperature and that this solubility increases rapidly once the melting point is passed. Therefore the danger from overheating must be obvious. Hydrogen is known to cause brittleness and hardness in electrolytic iron, and nitrogen in the form of iron-nitride is the source of extreme brittleness in welds made by fusion with the oxyacetylene blowpipe or with the electric arc.

No new constituent is directly traceable to the absorption of hydrogen. Nitrogen, however, is commonly found in the form of iron-nitride in acetylene and arc welds and in blown bessemer steel before the recarburizer has been added. Fig. 1 is of iron-nitride in a piece of nitrogenized iron wire. It shows isolated needles of iron-nitride and several areas of iron-iron nitride eutectoid.

The quantities of gases absorbed are exceedingly small when measured by weight, but when measured by volume in many cases they greatly exceed that of the steel—silver, for instance, having been known to absorb up to 200 times its volume of gases. Furthermore, when in their combined forms they furnish a very appreciable amount of impurity—for instance, 0.046 per cent oxygen in steel is equivalent to 0.2 per cent FeO, which is readily noticeable.

WILD HEATS

On casting overheated steel which has absorbed an excessive amount of gases a sudden evolution of gas is not unlikely, sometimes of such degree as to cause the metal to boil over in the molds. This may be due to evolution of hydrogen, nitrogen, etc., caused by the lowering of the solvent power of the metal for gases due to reduction of temperature or to the formation and giving off of CO or CO₂ formed through chemical reaction in the mold. Whatever the cause may be, the net result is blowholes and the production of unsound steel.

Wild heats are rare in good practice. Blowholes are almost always present in ingots, but may be so controlled that sound finished steel may be produced. "Killing" the steel in the furnace with ferrosilicon or by the addition of a little aluminum in the mold greatly reduces the liability to blowholes. This is not, however, good practice, as it is difficult to rid the steel of the oxidation products. It is thought that this reduction of blowholes is due to an increase in the solubility of the metal for gases caused by the silicon or aluminum additions. Blowholes which have become oxidized are not capable of being welded, but those with bright, unoxidized linings weld readily during forging or rolling.

An exceedingly high casting temperature should be avoided. This leads to unduly slow cooling, which in

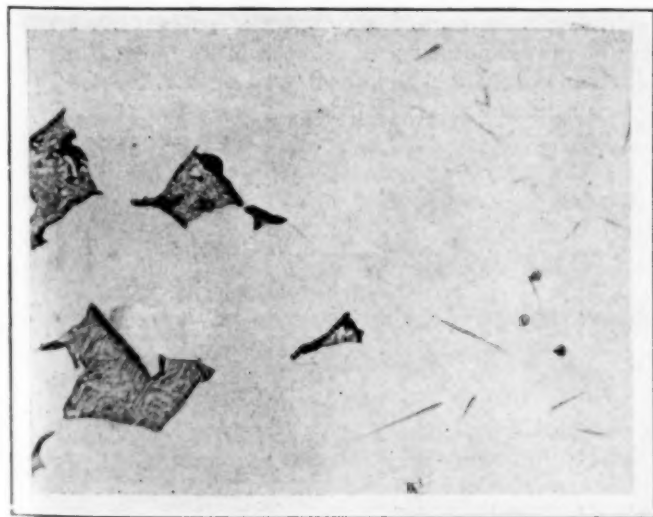


FIG. 1. EUTECTOID OF IRON AND IRON-NITRIDE, NEEDLES OF IRON-NITRIDE. $\times 400$. ETCHED WITH HNO₃

turn results in a very coarse structure and excessive segregation. In castings it is quite liable to cause cracks due to shrinkage, and even if cracks do not result at once severe internal strains may be set up which will exert an unfavorable influence upon the serviceability of the piece in question. Fig. 2 is a shrinkage crack found in a casting poured at too high a temperature.

Although in forged or rolled material the original coarse grains are usually broken up and refined and the segregation more or less removed by suitable heat treatment, this is frequently not the case with castings. These are as a rule submitted to a single annealing. This annealing may produce the desired result in so far as carbon distribution is concerned and yet may fall far short of producing a sufficiently well-annealed casting. Particularly is this the case in castings of nickel steel, in which, as is known, the nickel is present in solid solution with the iron. During and immediately after solidification all constituents of the steel are entirely in a state of solid solution; therefore it follows



FIG. 2. SHRINKAGE CRACK IN STEEL CASTING. $\times 200$

the laws governing freezing solid solutions—i.e., selective freezing takes place, producing the familiar cored dendritic structure with layers of varying composition. On cooling through the critical range pearlite is formed as usual, but so far as the metals which form solid solutions with iron when cold are concerned no change is produced. These metals are chromium, nickel, phosphorus, silicon, etc. Upon reheating above the critical

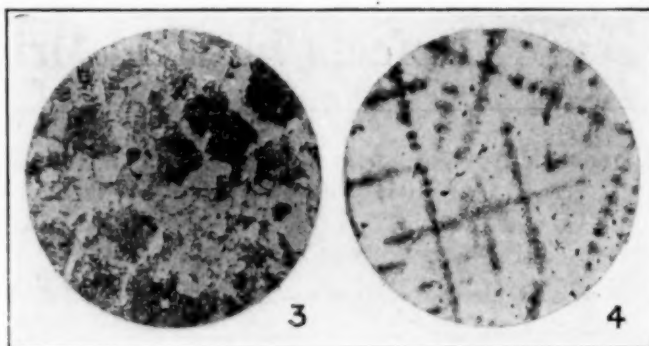


Fig. 3. Pearlite dark, ferrite light in nickel steel casting. Picric acid etching. $\times 300$.

Fig. 4. Dendrites shown by etching with cupric chloride, same steel as in Fig. 3. $\times 15$

point and allowing to cool either in air or the furnace we obtain a uniform structure of ferrite and pearlite, but still the original distribution of the nickel, phosphorus, etc., remains. To obtain the desired diffusion of this it is necessary to heat the metal to a high temperature for a long time, say 1,100 to 1,200 deg. for twenty-four hours, after which it is given the usual heat treatment to produce a fine pearlite structure. In Fig. 3 is shown the typical well-annealed pearlitic structure brought out with picric acid. Fig. 4 shows the coarse dendritic structure brought out with cupric chloride, the lighter areas being higher in nickel. Both are the same specimen of 3.5 nickel steel, and show the survival of a coarse dendritic structure even after proper distribution of the carbon has been attained.

NON-METALLIC INCLUSIONS

A prolific source of non-metallic inclusions in steel is in the admixture of foreign matter. This may be due in castings to loose grains of sand from the mold or from the abrading action of the stream of metal on the surface of the mold. In case of ingots for forging, rolling, etc., it may be due to insufficient cleaning of the molds.

An instance of this kind has recently come to the writer's attention. A slightly greenish substance (apparently some form of slag) was found in the center of a 4 x 4 in. soft steel billet. After polishing a microsection cut through this spot it was seen to have the appearance and structure shown in Fig. 5. The slag was composed of two constituents, one a light gray and the other a darker gray. The lighter gray spots were at first supposed to have been MnS , but a sulphur print showed little sulphur at that spot. It was de-

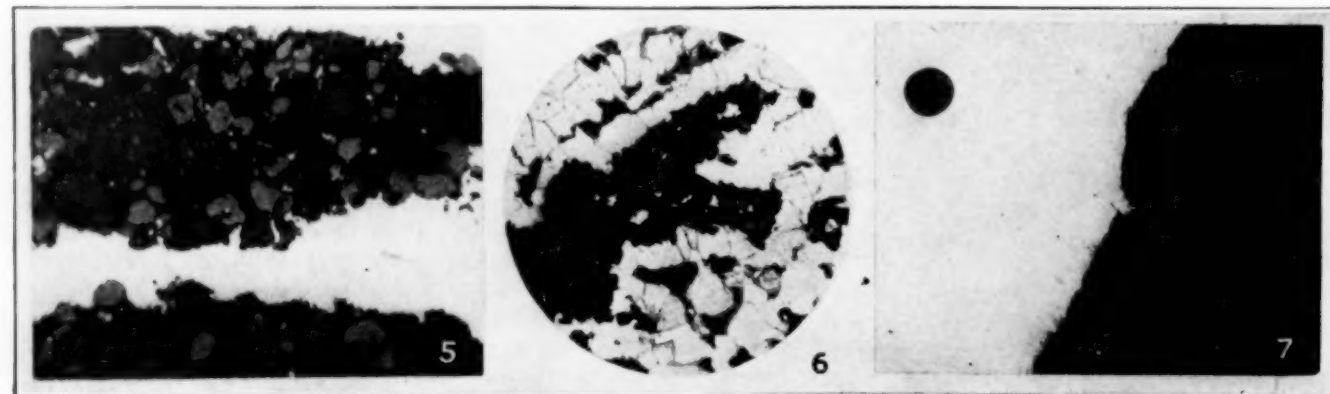


Fig. 5. Slag inclusion showing light and dark constituents interspersed with globules of steel. Unetched. $\times 150$.

Fig. 6. Same type of inclusion as in Fig. 5, after etching with nitric acid, showing lighter constituents eaten away. $\times 70$.

Fig. 7. Grains of sand sintered together, found in steel casting. Unetched. $\times 150$.

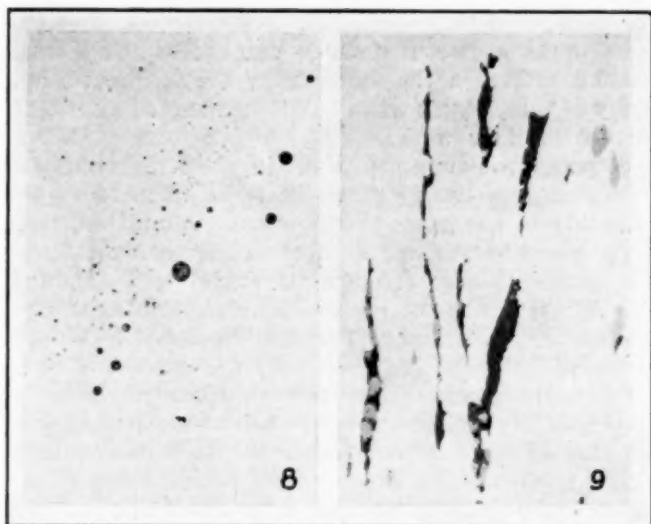


Fig. 8. Typical silicate inclusions in steel casting. Unetched. $\times 150$

Fig. 9. Typical silicate inclusions (darker) and MnS (lighter) in rolled steel. Unetched. $\times 150$

cided that the darker constituent was some basic substance high in lime, as it was readily attacked by HNO_3 , which is contrary to the behavior of silicates. Fig. 6 shows how the darker constituent was eaten away after etching it. It will be noticed that the slag is considerably broken up and evidently had been solid, not fused, at the time the steel entered the mold. The steel shows throughout as white masses. It was thought that this inclusion might have come from the lime wash used drying on the molds and then flaking

especially castings. It is supposed to heighten the solubility of the gases in the metal and thus prevent blowholes. It has a high affinity for oxygen and oxidizes readily to silica (SiO_2), reducing most of the oxides in the steel to their metallic form. Steel "killed" with silicon sets quietly with little evolution of gases. It may be added in the furnace, in the ladle or in the mold, usually in the form of ferrosilicon. Silica is acid and combines with iron and manganese oxides to form silicate slags. These silicates are sometimes mechanically trapped in the steel, especially if the steel has been treated with an excess of ferrosilicon. They are extremely hard and brittle and form dangerous discontinuities in the metal. Figs. 8 and 9 are examples of silicates in steel. Fig. 8 shows an exceedingly dirty spot in a steel casting, the silicates being present in the globular form commonly found in castings. The ferrosilicon in this case was added in the ladle. Fig. 9 shows typical elongated silicates found in rolled and forged materials. The darker inclusions are silicates and the lighter manganese sulphide. This photograph was taken from a low-carbon plate which had been "killed" by the addition of ferrosilicon in the mold. As a rule little objection can be raised to the use of silicon as a deoxidizer if not used in excessive amounts, although the danger of segregation such as shown in Figs. 8 and 9 is ever present.

MANGANESE SULPHIDE

Manganese is a deoxidizing agent to the use of which no defects can be attributed. Rather can they be charged to the lack of this element. Enough man-

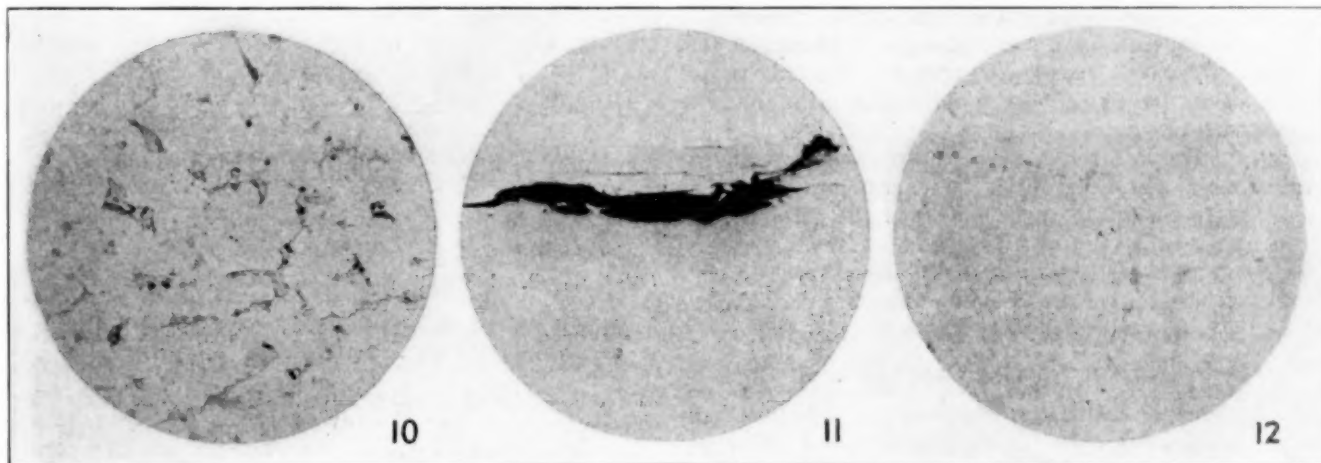


Fig. 10. FeS (lighter inclusions) segregated in skelp sample with a few dark pearlite patches. Etched with nitric acid. $\times 150$

Fig. 11. Crack (black) extending through segregated MnS in a failed rail. Unetched. $\times 150$

Fig. 12. MnS arranged around the grains in a steel casting. Unetched. $\times 150$

off when the steel entered. Subsequent investigation proved this theory correct.

Foreign materials also very frequently enter steel by the abrasion or fluxing of the stopper rods and ladle linings. Fig. 7 shows a number of grains of sand sintered together found in an acid open-hearth casting.

In dealing with the subject of defects in steel naturally the use and abuse of deoxidizing agents assume prime importance, since it is generally held that the larger number of non-metallic inclusions in steel, or "sonims" as they are now called, arise from this source. Silicon, manganese, aluminum and titanium are the principal deoxidizers used in the manufacture of steel.

Silicon is used extensively in producing sound steel,

manganese must be present to form MnS with all the sulphur, since if sufficient is not present the sulphur will combine with some of the iron to form FeS, which has an embrittling effect and which is the cause of "red-shortness" in the steel. Iron sulphide can be readily recognized under the microscope by its pale yellow color as distinct from the dove-gray color of MnS. Manganese to the extent of at least two and a half times the amount of the sulphur present is required to prevent the formation of FeS. Oftentimes, despite the fact that chemical analysis shows the presence of sufficient manganese, microscopic examination will reveal sections in which FeS predominates. This is due to sulphur segregating in one part of the steel to such

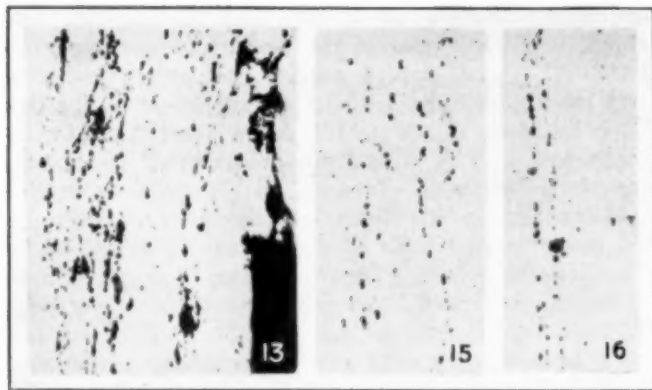


Fig. 13. Segregated alumina in web of failed rail, black area in corner is part of a crack. Unetched. $\times 100$

Fig. 15. Alumina streak shown as surface defect in Fig. 14. Unetched. $\times 100$

Fig. 16. Alumina streak found in piece of broken drill. Unetched. $\times 100$

an extent that sufficient manganese to satisfy it is not at hand in that particular spot. Fig. 10 is an illustration of such a case found in a skelp sample which analyzed 0.06 sulphur and 0.27 manganese. The sulphides shown in the photomicrograph are practically all in the form of FeS and were the cause of extreme "red-shortness."

Nevertheless the presence of all the sulphur as MnS does not entirely remove danger. Although there is little cause to fear sulphides in the form of MnS if uniformly distributed, their segregation is to be watched for. A group of MnS inclusions will cause a brittle spot in the steel which may well be the starting point of a crack. In Fig. 11 is shown a crack extending through a group of segregated MnS spots. This photograph was taken from a rail which failed in service and in which the above segregated spot was the only defect which could be found, the steel being clean and its microstructure good.

Fig. 12 shows streaks of MnS arranged around the grains of a steel casting. This arrangement of the sulphides has a weakening effect upon the material, but at the same time it is of a type frequently met with in well deoxidized castings. In most cases, however, this condition is not widespread enough to have very serious effect.

ALUMINUM AS A DEOXIDIZER

Probably the most detrimental as well as one of the most widely used deoxidizers is aluminum. The bad effects resulting from its use are so well known that many specifications, such as the A. R. A. specifications



FIG. 14. SURFACE DEFECT ON WRIST-PIN OF AIRPLANE MOTOR. NATURAL SIZE

for rails, positively forbid it. Nevertheless, in many steel works it is still common practice to add a small amount either in the ladle or in the mold, although many of these plants when questioned regarding it deny its use in their works.

Aluminum is supposed to act in much the same way as silicon in producing sound steel—i.e., it increases the solubility of the gases in the metal. Aluminum, however, has a very marked effect in increasing the viscosity of the slag through its oxidation to alumina (Al_2O_3), which is an exceedingly infusible substance, its melting point being around 2,000 deg. C. Thus it can easily be seen that it solidifies immediately upon its formation, the temperature of the steel being at least 300 deg. C. lower than this. Fine particles of alumina do not readily coalesce and therefore in spite of their low specific gravity have no tendency toward rising and on mixing with the other small slag particles retard their rise and cause the bath to become thick and pasty, thus favoring the production of dirty steel.

If no other reason were forthcoming the above ought to be sufficient to inhibit aluminum's use, but that is

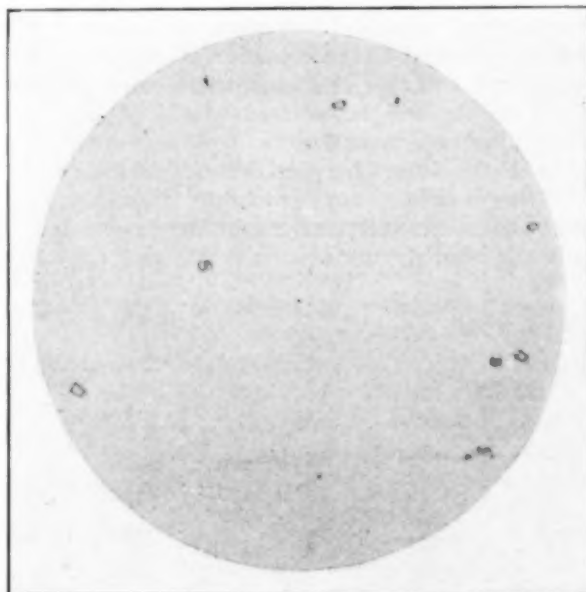


FIG. 17. TYPICAL TITANIUM-NITRIDE INCLUSIONS IN STEEL. UNETCHED. $\times 200$

not all. Although aluminum apparently has some effect in preventing the segregation of the constituents normal to steel, the particles of alumina exhibit a strong tendency to collect in large groups or masses which greatly reduce the strength of the steel. This is especially the case in worked material where streaks of alumina are often found, the weakening effect of which amounts almost to that of a crack. Fig. 13 shows a crack extending through a segregation of alumina found in the web of a failed rail. Fig. 14 shows a type of surface defect found in several hundred piston wrist-pins intended for airplane motors. The surface was ground from several of these pins to a depth of about $\frac{1}{16}$ in. and, the streak still remaining, it was polished and examined. Fig. 15 shows the streak of alumina as found with the aid of the microscope. Fig. 16 shows another exceedingly bad streak found in a specimen of broken drill steel. It is possible that the use at times of a very small quantity of aluminum, say a few ounces per ton, may be permissible, but at the same time the fact remains that even this is questionable.

FERRO-CARBON-TITANIUM

Although some metallurgists disagree, titanium in the form of ferro-carbon-titanium has been shown by many tests to be superior to all others as the final cleanser in steel-making. It cannot altogether replace either silicon or manganese, but it can take their place whenever they are used purely for deoxidizing purposes.

Titanium when added in the proper amounts makes the slag more fluid and acts as a flux for the various silicates. It has a high affinity for nitrogen as well as for oxygen, a property possessed by no other deoxidizer except possibly vanadium. It prevents segregation and does not itself segregate; in fact, except in high-carbon steels no microscopic constituent is found due to the titanium addition, and even in high-carbon steels it has never been known to segregate. When found in steels it is in the form of titanium-nitride, or rather titanium-cyanonitride, as it may be slightly contaminated with carbon. Fig. 17 shows typical titanium-nitride inclusions in steel.

In support of the views expressed above the writer quotes the following list of the properties of the various deoxidizers tabulated by Prof. Bradley Stoughton in the *Railway Age Gazette* of Feb. 7, 1913. The elements are given in the order of their effectiveness.

Prevention of blowholes 1, aluminum; 2, titanium; 3, silicon; 4, vanadium; 5, manganese.

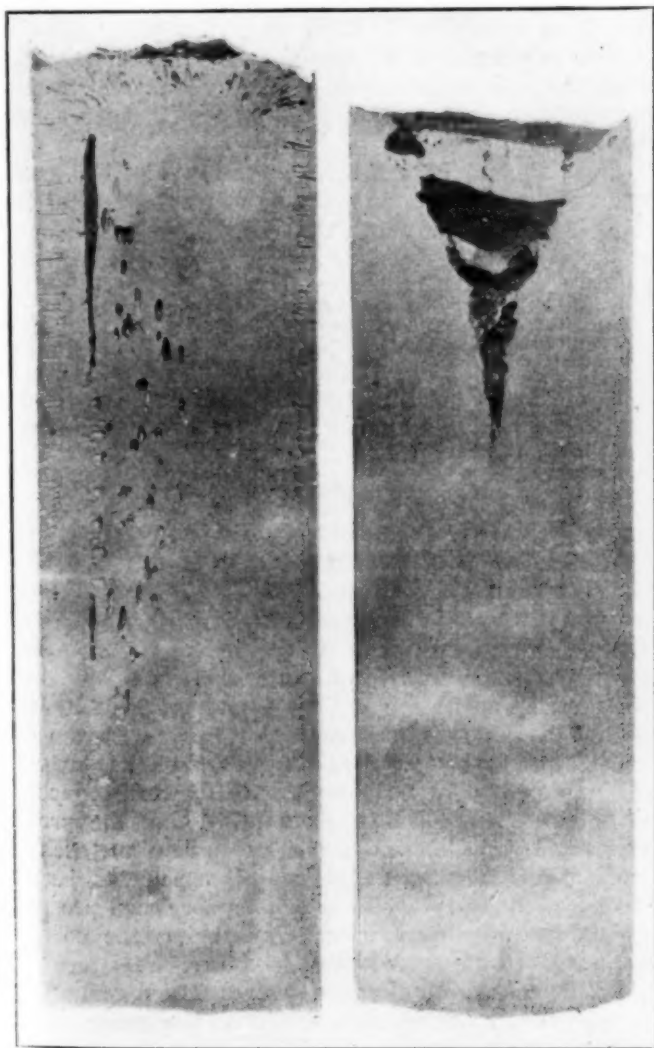


Fig. 18. A. Left—Ingot laid on side before final solidification. B. Right—Ingot cooled in normal position



FIG. 19. PIPE LINED WITH OXIDE, FOUND IN WEB OF AN "A" RAIL. UNETCHED. $\times 200$

Removal of oxides of iron and manganese: 1, titanium; 2, silicon (weakly). Hindering this removal: 1, aluminum; 2, manganese.

Removal of all oxides and slag enclosures: 1, titanium. Hindering removal of all these enclosures: 1, aluminum.

Removal of nitrogen: 1, titanium; 2, vanadium(?).

Breaking up and removal of iron-sulphides: 1, manganese; 2, titanium(?).

Causing a pipe: 1, aluminum; 2, silicon; 3, titanium; 4, vanadium; 5, manganese.

Hindering segregation: 1, aluminum; 2, titanium; 3, vanadium. Promotion of segregation: 1, manganese; 2, silicon (sometimes).

PIPING

During the solidification of ingots a certain amount of piping, segregation and formation of blowholes is almost sure to occur. It is not possible to prevent entirely all these conditions, but the difference in the degree to which they are overcome constitutes much of the difference between good and poor practice.

A "pipe" in an ingot is in reality a shrinkage cavity, caused by contraction in cooling. The metal at the bottom and sides is cooled first by the chilling effect of the mold, and as it contracts is fed by the fluid metal in the center and top, with the result that a cavity forms in the top portion of the ingot. If cooled equally on all sides the "pipe" will occur in the center of the top of the ingot. If the ingot is "capped"—i.e., has a cast-iron plate clamped over the top as soon as filled to cause immediate solidification of the top—the "pipe" may be some distance below the top of the ingot. That a "pipe" is a shrinkage cavity has been proved by laying an ingot on its side before final solidification has taken place. In this case the "pipe" was distributed on the upper side along the length of the ingot instead of being confined to the top part. Fig. 18 A is a photograph of an ingot which had been laid on its side before final solidification, as just described. Compare this with B, which shows the normal occurrence of a "pipe"—i.e., in the top central portion of the ingot. The use of aluminum, silicon or any deoxidizer which causes the metal to set quietly increases "pipe" and usually necessitates the scrapping of a proportionately larger amount of metal.

Theoretically it should be possible to cast steel without producing a "pipe." This would be done by casting the metal at such a low temperature that solidification would take place the instant the steel entered the mold, the shrinkage thus being taken care of as the mold filled. Practically such accurate temperature control is not possible. The metal must be at a high enough temperature when tapped from the furnace to



Fig. 20. Sulphur print showing segregation in "A" rail rolled from top of an ingot

Fig. 21. Sulphur print showing absence of segregation in "E" rail rolled from bottom of same ingot as "A" rail in Fig. 20

permit of teeming, and a safe margin must be allowed for any reasonable delay.

Blowholes can be so regulated that they occur only in places and under conditions which allow of their being welded in the subsequent forging or rolling operations.

Many ideas have been advanced for the production of sound steel ingots. Most of the plans put forward have been based upon the compression of the still liquid steel. Hadfield has suggested keeping the top of the ingot fluid by means of a charcoal fire and a blast of air, thus furnishing a "head" of liquid metal. Sound steel has been produced by almost all the methods suggested, but various reasons, usually cost of equipment or operation, have militated against their adoption.

The most practical method yet devised is the use of "hot-tops." A hollow fireclay tile is fitted on the

top of each ingot mold and when the ingot is teemed this is also filled. As the tile does not have the same chilling effect as the sides of the mold the metal contained therein remains fluid and by gravity feeds the metal in the mold as it contracts. Thus the entire "pipe" is usually confined to the "hot-top" and is easily removed by proper cropping. Since "piping" occurs in all steel where metallic shrinkage is not balanced by gas evolution (blowholes) and must be removed by cropping, it will be easily understood that a defect called a "pipe" in the finished product is in reality due to insufficient cropping. Fig. 19 illustrates the remains of a "pipe" found in a sample of rail.

SEGREGATION

Primarily segregation is due to the phenomenon known as selective freezing. This merely means that due to the various impurities it contains all portions of a steel ingot do not solidify simultaneously. When the liquidus of the particular alloy is first passed that part of the metal which is relatively more infusible solidifies. The more fusible portions—i.e., the portions containing the impurities—naturally solidify last and therefore are found in that portion of the ingot which is the last to freeze, usually the top central portion. Carbon, sulphur and phosphorus as well as most of the non-metallic inclusions tend strongly toward segregation when opportunity offers. Some of this segregation can be removed by proper heat treatment, but there is no remedy other than "cropping" for any serious segregation of non-metallic inclusions. The evil effects of segregation are many and will be encountered throughout the entire process if not properly dealt with.

Figs. 20 and 21 are sulphur prints of 90-lb. rails rolled from near the top and bottom respectively of the same ingot. Fig. 20 shows the typical segregation found at the top of the ingot. Fig. 21 shows a good homogeneous metal.

Fig. 22 illustrates the poor distribution of pearlite in a low carbon sheet-bar due to segregation in the ingot. At this stage of the manufacture it is impossible to correct this structure entirely, although it may to some extent be modified by suitable heat-treatment.

Niagara Falls, N. Y.

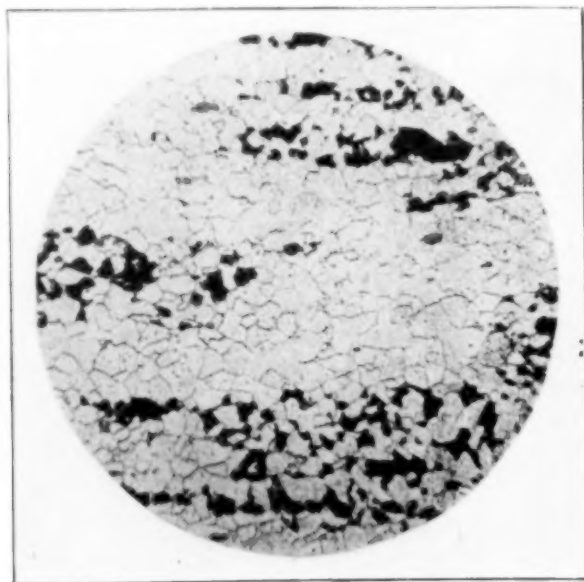


FIG. 22. SEGREGATION OF PEARLITE IN STRIP STEEL. ETCHED WITH NITRIC ACID. $\times 100$

World's Industrial Exhibition in London in 1922

Announcement is made of a world's industrial exhibition, to be held at the Crystal Palace, London, during the months of May to October, 1922, of the industries, products, arts, sciences and inventions of the leading manufacturing countries of the world. It will be on a co-operative basis, the capital being provided by the exhibitors and those otherwise connected with the exhibition (such as the guarantors of each nation who guarantee sufficient for the preliminary work connected with the exhibition of their nation), and the profits accruing from the various sources of revenue, such as contracts for advertising, catering, amusements, season tickets, gate receipts, etc., will be apportioned pro rata among the exhibitors in order to bring the cost of exhibiting to the lowest possible figure.

Each country will elect its own exhibition committee, which in turn will be represented on the general committee. The management will be under the control of a committee representing the exhibitors and guarantors generally.

Possibilities for Research and Development in the Field of Refractories*

A Review of the Main Economic and Technical Factors Which Are to Be Taken Into Account When Research Work Is to Be Pursued on Some Particular Phase of the Industry of Refractories

By HOMER F. STALEY†

THE increasing use of refractories in well-known ways and the numerous demands for various kinds of refractories to be used for new purposes have created a demand for research. Moreover, the high price commanded by all sorts of refractories in the past few years has held forth the possibility of large pecuniary rewards as the result of successful research in this field. For these reasons there has been conducted of late a large amount of research dealing with refractories, some of which has been well planned and conducted along logical lines of procedure, but part of which has been ill-advised and from the very nature of the case doomed to produce no results of industrial importance.

It may be well then to make a brief survey of the field of refractories and to point out some of the phases of manufacture of these materials in which there is room for research and development.

ECONOMIC PHASES OF THE SUBJECT

If results of an industrial research are to be of large financial importance they must deal with some refractory which is or can be used in quantities with a high money value. In the accompanying table are given the value of the various refractories used annually in this country. It will be noted that out of the total of approximately \$72,000,000 \$44,000,000 represents the value of the clay refractories. Second in rank comes silica brick, with a value of \$20,000,000. Third in rank are magnesite refractories, with a value of \$6,500,000, while the bauxite and chromite refractories have a small annual value of about \$650,000 each. Therefore from a monetary standpoint the big opportunities for research are in fields of clay, silica and magnesite refractories.

Of the clay refractories, firebrick represent an annual value of \$36,000,000; glass pots and other glass house refractories a value of \$3,000,000; chemical porcelain and chemical stoneware of a little less than \$2,000,000; zinc retorts of a little over \$1,000,000, while all other clay refractories, including stove linings, saggers, mantle rings, muffles and crucibles, pottery supplies and miscellaneous materials, have a combined value of only \$2,000,000. It is evident, therefore, that the opportunities for research in clay refractories which may result in the saving of many millions of dollars annually lie in the possibility of improving the quality of firebrick, in lessening the cost of manufacture of these, or in producing a new product which can be used more economically. Research in other clay refractories

or in finding substitutes for these may result in moderate pecuniary reward to the investigator, but the product will probably never have a large annual value. If improvements can be made in the method of manufacturing silica and magnesite refractories, or if more economic substitutes can be found for these, the results of such research may possibly have large financial importance.

It should be remembered that the cost of refractories to be used for a certain purpose cannot be stated in terms of cost for unit of service. For instance, in the steel industry the cost of refractories is measured as cost of refractories per unit of steel produced. The item "cost of refractories" includes cost of firebrick and mortar, cost of repairs, including the charge for tearing out old material and replacing it by new, and, when two materials are being compared, the cost of interruption to manufacture incidental to the necessity for more frequent repairs when using one material than

ANNUAL PRODUCTION OF REFRACTORY PRODUCTS IN THE UNITED STATES

Clay refractories:	
Firebrick.....	\$36,000,000
Glass house refractories.....	3,000,000
Chemical porcelain and chemical stoneware.....	1,750,000
Zinc retorts.....	1,200,000
Stove linings.....	675,000
Saggers.....	600,000
Potters pins, stilts and spurs.....	275,000
Mantle rings, electrical resistance units, etc.....	250,000
Muffles, assay supplies and crucibles.....	150,000
Miscellaneous.....	100,000
	\$44,000,000
Silica brick.....	\$20,000,000
Magnesite refractories.....	16,500,000
Bauxite refractories.....	1,650,000
Chromite refractories.....	1,650,000
	\$71,800,000

* This amount is the estimate of the U. S. Geological Survey for the year 1919.

† Estimate of the writer. The other amounts are rounded figures taken from those given in Mineral Resources of the United States, 1918, Part II.

when using another. In the same way in the pottery industry the actual cost of saggers is only incidental to the loss of ware and production caused by the breakage and failure of saggers. It may thus happen that an industry would be willing to pay more money for a refractory to use for certain purposes than it is now paying, provided the cost per unit of service with the new refractory is less than that with the one now being used.

In conducting a research to determine the probable life or service to be obtained from a new refractory care must be taken to consider the actual conditions of service in the industry. For instance, it has been demonstrated by laboratory tests that certain rather expensive sagger mixtures are more resistant to repeated heating and cooling and have higher transverse

*Paper presented at Chemical Exposition, New York City, Sept. 24, 1920.

†Chief Refractories Section, Bureau of Standards, Washington, D. C.

strength at high temperatures than those now in use. When these mixtures were tried out in actual practice in factories it was found that the breakage due to rough handling in setting and drawing kilns was so great that the estimated life of these saggers was reduced to the point where it was not profitable to use them. In another instance the use of fused alumina brick seemed to promise to be very satisfactory for the use of roof of electric furnaces. These brick were very refractory and showed marked ability to withstand sudden changes of temperature. However, when they were used in the roof of an electric furnace it was found that they failed, due to the fluxing action of lime vapors in the furnace.¹ There is no question that brick could be made from more expensive materials which would be more resistant than firebrick to the temperature conditions and the slags used in blast furnaces; but these brick would be subjected to abrasion the same as the cheap firebrick now being used, and for this reason probably would not prove economical in use. We may rather definitely assume, therefore, that under existing conditions in a well-established industry none of the refractories now in common use are liable to be replaced by new refractories with comparatively excessive first costs.

On account of the importance of the practical and economic phases of research in refractories makers and users of these materials should work in conjunction with scientific research men. A rather ideal body for the formulation of research programs is one similar to that of Committee C-8 of the American Society for Testing Materials, which is composed of an equal number of representatives of manufacturers of refractories, of users of refractory wares and of men from research laboratories.

IMPROVEMENT IN CLAY REFRACTORIES —PHASE-RULE INVESTIGATION

Fireclays are essentially silicates of alumina carrying varying amounts of free silica in the form of sand and small amounts of potash, soda, lime, magnesia, iron and titanium. The phase-rule diagrams showing the effect of most of these materials on aluminum silicate have been worked out sufficiently to enable us to say that little is to be learned in regard to the practical utilization of clays done for refractory purposes by further application of phase rule studies.

The most important information obtained from these studies has been that calcined kaolinite must be considered as one point on the sillimanite-silica diagram. The eutectic between sillimanite and silica consists of 84 per cent silica and 16 per cent sillimanite, corresponding to 90 per cent silica and 10 per cent alumina.² It follows that the amount of silica-alumina eutectic in a clay is found by multiplying the percentage of silica in the calcined clay by $1\frac{1}{3}$. We can thus calculate that even in pure kaolinite 60 per cent of the calcined clay will melt at the eutectic temperature. The work of Montgomery and Fulton³ and other investigators has shown that the eutectic between silica and sillimanite is the dominating one in clays and that the effect of other impurities is simply to lower the eutectic temperature and to increase the amount of eutectic without

materially altering the ratio of silica and alumina entering into the eutectic. We may thus say that whenever the temperature is reached at which the silica-sillimanite eutectic becomes active the clay refractory consists of at least 60 per cent of melted material carrying the remainder of the refractories as unmelted material. The clay mass as a whole then gradually softens and becomes useless in refractory construction. The temperature at which this occurs varies with the composition of the clay and the structure of the mass, and the type of construction in which the material is used. In general we may say that clay refractories are not suitable for continuous use under load at temperatures above 1,350 deg. C., nor for use in structures where they are not subjected to load at temperatures above 1,450 or 1,500 deg. C.

PERMANENCE OF VOLUME

All clay refractories shrink during firing and when used in comparatively high temperatures are liable to continue to shrink. This lack of permanence of volume in use is one of the most flagrant defects of different types of clay refractories. In most cases it cannot be overcome, as is commonly assumed, by firing the refractory to a temperature equal to or slightly above that at which it is to be used. This shrinkage in use can be minimized by proper firing temperature, by selection of clays, by selection and preparation of grog material, and by variation in methods of manufacture. There is room for considerable research in developing clay refractories that will be permanent in volume up to temperatures of 1,350 to 1,450 deg. C.

GLASS HOUSE REFRACTORIES

During the past few years active research work has been done by a number of laboratories and by various individuals in connection with the improvement in glass house refractories. The most profitable line of research has dealt with the selection of clays, the preparation and sizing of grog and methods of manufacture. It is hoped that this work will be continued.

ZINC RETORTS

In microscopic study of used zinc retorts it has been shown that when clay retorts have been used for some time they are converted into what is essentially a mass of zinc spinel crystals. The possibility of making retorts from zinc spinel should be investigated.

SAGGERS

As stated above, while the annual charge for saggers in the pottery industry does not amount to a large sum, yet the loss of ware and production due to breaking of saggers is an important item in the pottery industry. It has been demonstrated that considerable improvement can be made in the length of the life of saggers by proper selection of clay both for bond clays and for grog and by proper sizing of grog. The use of such materials as sillimanite and carborundum for saggers is worthy of further study.

CHEMICAL PORCELAIN

While some of the chemical porcelain that has been made in this country has been of excellent quality, some has not. As far as use of clay ware for this purpose is concerned it seems that research and development should deal in this field of true high fire porcelain with glazes maturing at high temperatures. Since the

¹F. A. J. FitzGerald, *CHEM. & MET. ENG.*, vol. 22, No. 10, p. 129 (1920).

²Shepherd, Rankin and Wright, *Am. J. Sci.* (4th ser.), vol. 28, p. 293 (1909). See also *Collected Writings of Herman A. Seger*, p. 545 (pub. by Am. Ceram. Soc., 1902).

³*Trans. Am. Ceram. Soc.*, vol. 19, p. 303 (1917).

amount of body material used in this type of ware is small compared to the value of the finished product the use of some of the more rare and expensive materials in place of, or in combination with, clay has interesting possibilities.

MANTLE RINGS, ELECTRICAL RESISTANCE UNITS AND SIMILAR SPECIALTIES

While these are commonly classed as clay refractories, the use of pure magnesia and other special refractories in these in combination with clay is quite common, and there seems to be an opportunity for development of the use of various refractory oxides in these fields.

KAOLIN REFRACTORIES

Up to the present time practically all the clay refractories manufactured in this country have been made from fireclays. The use of kaolin as a refractory has been tried in an experimental way, and it has been shown that it can be employed to make a very high-grade clay refractory. The use of this material should be investigated further.

SILLIMANITE REFRACTORIES

As stated above, calcined clay represents one point in the silica-sillimanite eutectic series. By adding alumina to clay it is possible to get a composition that corresponds essentially to the mineral sillimanite $\text{Al}_2\text{O}_3\text{SiO}_2$. The most simple way of making sillimanite is by adding an ore of alumina to clay so as to bring the silica-alumina ratio up to that of sillimanite and then to burn the mixture in a kiln at a temperature not less than cone 18. Sillimanite can be made also by fusing a mixture of clay and coke in a cupola furnace and volatilizing the excess silica. This method has been used by Lacesne⁴ in France and Malinovszky⁵ in this country. Since with many ores of alumina there is a shrinkage in the formation of sillimanite in the kiln process, when these are used sillimanite must be made in one firing and the resulting material must be ground and mixed with a binder for the formation of wares which are then subjected to firing. Raw sillimanite mixture is a suitable binder for sillimanite made in this way or by the furnace process. A few ores of alumina, notably certain varieties of the diaspore clays found in Missouri, have so low fire shrinkage that it is possible to use them in connection with clay of low fire shrinkage for the manufacture of sillimanite wares in a one-fire process.

These sillimanite refractories have very desirable properties. The melting point is above cone 34, they do not soften at temperatures much lower than the melting point. When properly made they have permanent volume at elevated temperatures and resist sudden changes in temperature well. Up to the present time practically the only commercial use that has been made of this refractory has been in the manufacture of pyrometer tubes from what is known as Marquardt porcelain. There is a possibility of these refractories being used successfully for making saggars and crucibles and other refractories to be used at temperatures above those at which clay refractories give satisfactory service. For use in electric-furnace construction they have the advantage over silica refractories in that they are

not subject to destruction through volume changes. They are superior to carborundum refractories in that they do not deteriorate when they are used either under oxidizing or reducing conditions at high temperatures.

SILICA REFRACTORIES

The manufacture of silica brick in bulk shapes for furnace construction is the only important use of silica as a refractory in this country. We do not class fused silica ware, commonly called quartz glass, as refractory material. The making of silica brick has long been conducted successfully in this country by empirical processes, and the theoretical foundation of these has been studied thoroughly in the last few years.⁶ These have shown that the fundamental necessity for firing silica at high temperatures is due to the necessity for converting quartz into cristobalite and tridymite so as to avoid the volume changes undergone by quartz in heating and cooling. The one inherent defect of silica brick is that the cristobalite, which comprises their bulk constituent, is subject to sudden expansion when heated above 230 to 270 deg. C. and contraction when cooled below that temperature range. Therefore silica brick are not suitable for structures which are to be cooled periodically to atmospheric temperatures, but are very satisfactory for structures which are to be held continuously at high temperatures.

It is not probable that any improvement of marked commercial importance will be made by researches in silica brick manufacture. New uses can probably be found for these brick in structures that are to be held continuously at high temperatures. A promising field for study of uses for silica brick is in the construction of car-tunnel kilns.

MAGNESITE REFRACTORIES

Magnesite refractories are used for construction of those parts of metallurgical furnaces which come in contact with basic slag. The properties and processes of manufacture of these brick are fairly well understood. Their use is limited largely by the fact that they do not stand sudden temperature changes well and also are liable to shrink when held at high temperatures for long periods of time. Both these objections can be overcome by use of electrically fused magnesite with temporary organic binders or a small amount of raw magnesite as binder. This has been tried out on a small scale and the wares produced have been quite permanent in volume when exposed to high temperatures for long periods of time. Above 1,800 deg. C. they deteriorate by volatilization. It is probable that the use of electrically fused magnesite as a refractory will be employed for a special high-priced construction for the linings of electric furnaces.

Another magnesite refractory that shows promise of development is that of magnesium spinel, $\text{MgO} \cdot \text{Al}_2\text{O}_3$. This spinel can be made by calcining at high temperatures a mixture of magnesite and alumina ore. The calcined product can be made into wares by using small amount of the raw mixture as binder. Wares made in this way do not soften or deform below 1,800 deg. C. and do not deteriorate due to the volatilization of magnesia in the same way as pure magnesia refractories. The making of such refractories has been tried on a laboratory scale, and their use for the making of

⁴J. Am. Ceram. Soc., vol. 3, p. 40 (1920).

⁵J. Am. Ceram. Soc., vol. 3, p. 160 (1920).

⁶C. N. Fenner, *Am. Jour. Sci.* (4th ser.), vol. 36, p. 339. D. W. Ross, Tech. Paper, Bureau Standards, 116.

small quantities of special comparatively high-priced refractories such as crucibles and pyrometer tubes seems a possible development.

CARBORUNDUM REFRACTORIES

In the past few years the use of carborundum refractories has reached a certain amount of commercial importance. The first attempts were made to bind the carborundum with clay, but lately it has been found possible to manufacture carborundum articles simply with the use of a temporary binder such as linseed oil, gluten or pitch. When the wares thus formed are fired to a high temperature, the temporary binder is burned out and the grains of carborundum are bound into a hard mass by the formation of carborundum crystals. Wares made in this way do not melt at any temperature, but dissociate and oxidize into silica and carbon very rapidly at 2,200 deg. C. This dissociation and oxidation are noticeable under oxidizing conditions at 1,500 deg. C. and under reducing conditions at temperatures above 1,700 deg. C. This refractory has the advantage over silica and magnesia refractories in that it is inert to basic and acid slags and that it is very resistant to all temperature changes. It can be used continuously at higher temperatures than either silica or calcined magnesite refractories. The heat conductivity is very high, which is an advantage for some purposes and a disadvantage for others. It has been used with satisfaction for the roofs of electric furnaces, but in such cases it has been necessary to cover the roof with a heat-insulating layer of firebrick and arrange to avoid contact of electrodes with any part of the roof. This latter caution has been found necessary on account of the high conductivity for electricity of carborundum refractories at high temperatures. It is probable that other uses will be found for this material.

ALUMINA REFRACTORIES

At present about the only use of bauxite brick is for the lining of the hot zone of rotary cement kilns. The factor that militates against its general use is the tendency to shrink continuously when exposed to high temperatures.

The use of fused alumina has been experimented with in the last few years. Products made from this material have constant volume and a high melting point. One difficulty has been to find a satisfactory binder. Clays have been used but the wares softened and deformed at the melting point of the clay used as binder. The use of raw mixtures which will form alumina compounds, such as magnesia spinel, as binders for this sort of material has been tried with promising results. Fused alumina materials up to the present have been used for making special small high-priced refractory pieces such as parts for electric tube furnaces, crucibles for chemical work, etc. There seems to be a field for this material in such uses, but it is not probable that it will ever be used for heavy refractory wares.

ZIRCONIA REFRACTORIES

Zirconia refractories have attracted a large amount of attention in the past few years. Zirconia ore from South America containing about 75 per cent ZrO_2 , the chief impurity being silica, has been used for making crucibles, brick and other refractories. Clay was tried as a binder at first, but it reduced the melting point of the refractory very remarkably. At present

finely ground ore is being used successfully as a binder. These wares must be fired to quite a high temperature if they are to be permanent in volume when exposed continuously to heat. The use of zirconium silicate, which is found in commercial quantities in this country, also gives promise of development. Attempts have been made to use pure zirconium oxide as a refractory for special purposes. In order to secure materials that do not crack in firing and change in volume and use, it has been found necessary to calcine the zirconium oxide at a very high temperature. In fact, the simplest method seems to be to fuse the zirconia in an arc. Since zirconia has a very high melting point, its use to a limited extent for refractories to be used at exceedingly high temperatures seems to be worthy of investigation.

CARBIDES AND NITRIDES

Of course, for continuous use under certain conditions it is essential that a refractory element be in a chemical combination which is stable under those conditions. For instance, in electric-furnace work it has been found that many of the refractory elements such as magnesium, titanium and aluminum form carbides when in contact with carbon or carbon vapors and that other elements under certain conditions at high temperatures form nitrides. This has logically led to researches having for their object the use of carbides and nitrides for refractories under the conditions stated. The employment of none of these materials has reached the stage of commercial importance at present, but active research along these lines is being conducted and should be continued.

REFRACTORY COATINGS

The technical literature in the patent records for the past few years has been full of references to attempts to use comparatively high-priced refractory materials for coatings for cheaper refractory materials. Some of these have been technically rather foolish—for instance, the use of thin coatings of carborundum to protect other refractories from the effect of heat. The conductivity of carborundum refractories is so high that the thin coating offers practically no protection against heat. Other futile attempts have been made to put coatings on refractory material when the coefficient of expansion or the shrinkage in use of the two materials varies materially. Another instance is the use of coatings or paints to produce a glazed surface on refractory materials. All such glazes reduce the refractoriness of the material so coated. Quite often the glaze is produced by the use of sodium silicate, which of course is a very effective flux. Such coatings may improve density and mechanical strength of the surface and thus protect the refractory against abrasion, the cutting action of flames, or against penetration by slag, but they certainly do not make the ware more resistant to heat. Similar compositions have been used for mortars in the building of refractory structures. There is no doubt that in some respects there is room for improvement over the common practice of using a fireclay chosen simply for its refractory properties. As mortars in structures subjected to cutting action of flames or corrosive action of slags, a vitrifying mortar would be more satisfactory. In any structure a vitrifying or semi-vitrifying mortar gives a structure that is stronger from the standpoint of mechanical strength. However, the composition of the material used for vitrifying mortar should be studied with care. Some of those

that have been proposed have been found injurious. There is room for research in the question of mortars for refractory structures.

INSULATING MATERIALS

At present the use of refractory material is in many cases dependent upon the fact that part of the refractory is kept comparatively cool by radiation. An instance is the use of refractories in the roof of metallurgical furnaces and ceramic kilns. Of course this radiation involves loss of a large amount of money. On account of the increase in cost of fuel in the past few years, the use of insulating materials for refractory structures has received considerable attention. It has been found in a number of cases that when the structure was insulated against loss of heat and the refractory materials thus became heated to a high temperature, they immediately failed. It is probable that if the use of heat-insulating coatings for refractory materials becomes common, the whole status of the use of various refractories in such structures will be materially changed and a revolution in the manufacture and use of refractories will take place. It will probably be necessary to use more expensive refractories and to develop the more general use of those now used but little. In certain cases it has been found that when insulating materials were used, the interior of the furnace walls became so hot that the insulating material failed, not by fusion, but by shrinkage. In connection with the use of some of the very high-grade refractories, there is need for the development of an insulating material which will function satisfactorily at high temperatures. In fact, it may be said that the whole question of the construction of electric furnaces with the use of high-grade refractories waits on the development of such an insulating material.

SUMMARY

Several factors must be taken into account when considering the possibilities for research in a particular phase of refractory industry or the development of the use of a new material as a refractory. The technical questions are the ones that are liable to seem most important to the research man, but the economic phases of the subject are fully as important. A certain amount of prevision is essential in considering such problems. A change in economic conditions or in modification of the methods of use of refractories may alter entirely the whole question of the manufacture of refractories and the possibility of the economic development of new refractories.

Improvement of Shantung Silk

An international committee for the improvement of Shantung silk has been organized at Chefoo, according to advices from Commercial Attaché Julean Arnold. For this purpose the Chinese Government has sanctioned the use of part of the export tax on silk from Chefoo, so that a sum of 150,000 taels (\$200,000) will be available annually for development and improvement work. Five hundred thousand mulberry trees are being purchased to aid in the development of mulberry silk. It is the aim of the association to improve both mulberry and tussah silk, which is produced by oak-leaf-fed silkworms, and it is hoped that through improved methods of reeling and the Pasteur method of egg selection greater market possibilities in America may be opened.

The Canadian Starch and Glucose Industry

The starch and glucose industry in Canada embraced twelve establishments in 1918, and the same number in 1917. The value of the total assets of the industry increased from \$3,670,806 in 1917 to \$3,784,664 in 1918, or 3 per cent. Included in this total, reports Consul Johnson, of Kingston, Ont., is the value of lands, buildings, fixtures, machinery, tools, materials on hand, stocks in process, finished products, fuel and miscellaneous supplies, which decreased from \$3,218,216 in 1917 to \$3,112,311 in 1918.

This leaves the increase in the cash and trading accounts at \$219,763, or 48.5 per cent.

EMPLOYEES AND WAGES—MISCELLANEOUS EXPENSES

In 1917 there were seventy-six salaried employees in this industry, who received a total of \$92,312, of which \$48,865 was paid to managers. In 1918 there were seventy-one in this class, receiving in the aggregate \$98,595, managers receiving \$49,440. This gives a per capita payment to salaried employees of \$1,215 in 1917 and \$1,389 in 1918. The average number of wage earners employed increased from 615 in 1917 to 633 in 1918; the total payment in wages rose from \$428,723 in 1917, to \$541,550 in 1918, or a per capita rating of \$697 in 1917 and \$856 in the succeeding year.

Miscellaneous expenses other than fuel, power, labor and raw materials, chargeable against manufacturing operations, rose from \$268,938 in 1917 to \$339,763 in 1918.

RAW MATERIALS USED

Approximately \$5,000,000 worth of raw materials was consumed by the industry in 1918, the chief items being as shown in the following table:

Corn (139,974,408 lb.)	\$3,858,312
Potatoes (9,923,279 lb.)	106,064
Cornstarch (503,950 lb.)	32,495
Sugar and sirup for mixing (1,657,082 lb.)	113,399
Containers of all kinds	750,560
Chemicals	44,763
All other miscellaneous materials	87,112
Total	\$4,992,705

Cornstarch was used in one factory to make dextrine exclusively, but in three other plants it was used for the manufacture of both glucose and dextrine, so that it is not possible to determine the amount of starch utilized in the manufacture of either of these products. The principal commodity in the item "chemicals" is hydrochloric acid, which is used principally for the manufacture of glucose by the hydrolysis of starch.

PRODUCTS OF THE INDUSTRY

The industry's output in 1918 was valued (at the factory) at \$7,620,864, starch of various kinds and glucose forming \$6,327,515 of this total, as the following table shows:

Products	Quantity	Value
Cornstarch, lb.	19,041,506	\$1,445,324
Laundry starch, lb.	4,820,377	391,456
Potato starch, lb.	2,055,472	177,353
Chinese starch, lb.	1,263,227	122,284
Glucose (including all sirups), lb.	64,803,113	4,191,098
Grape sugar, lb.	689,378	37,392
Corn oil, gal.	242,451	404,659
Stock feed, tons	14,510	796,349
Dextrine, lb.	655,070	54,949
Total		\$7,620,864

Effect of Fittings on Flow of Fluids Through Pipe Lines

DEAN E. FOSTER presented the accompanying pipe-fitting equivalent tables and steam flow chart at the annual meeting of the A.S.M.E., New York, Dec. 7-10. To illustrate, an example may be taken of a 6-in. steam line 1,000 ft. long, containing five gate valves, three angle valves, twenty standard tees and ten standard elbows. From the lower table for vapors, these fittings are found to be equivalent to 332.10 ft. of 6-in. pipe, as follows:

5 Gate valves @ 4.81.....	24.05
3 Angle valves @ 17.35.....	52.05
20 Standard tees @ 6.35.....	127.00
10 Standard elbows @ 12.90.....	129.00
Total allowance.....	332.10
Actual pipe length.....	1000.00
Equivalent total length.....	1332.10

The chart shows that with an initial pressure of 150 lb. and a total loss of 5 lb. pressure or 0.375 lb. per 100 ft. this line will transmit 225 lb. of steam per minute. If the effect of the valves and fittings had been ignored, the calculation would show a capacity of 260 lb. of steam per minute.

The upper table for liquid flow is used in conjunction with standard tables, Cox's flow of water through pipes, etc., in a similar manner. In both formulas,

L_e = feet of pipe equivalent to fitting.

d = diameter of pipe in inches.

r = factor of resistance.

STANDARD PIPE EQUIVALENTS TO ALLOW FOR FITTINGS IN CONDUITS CARRYING NON-VISCOUS LIQUIDS

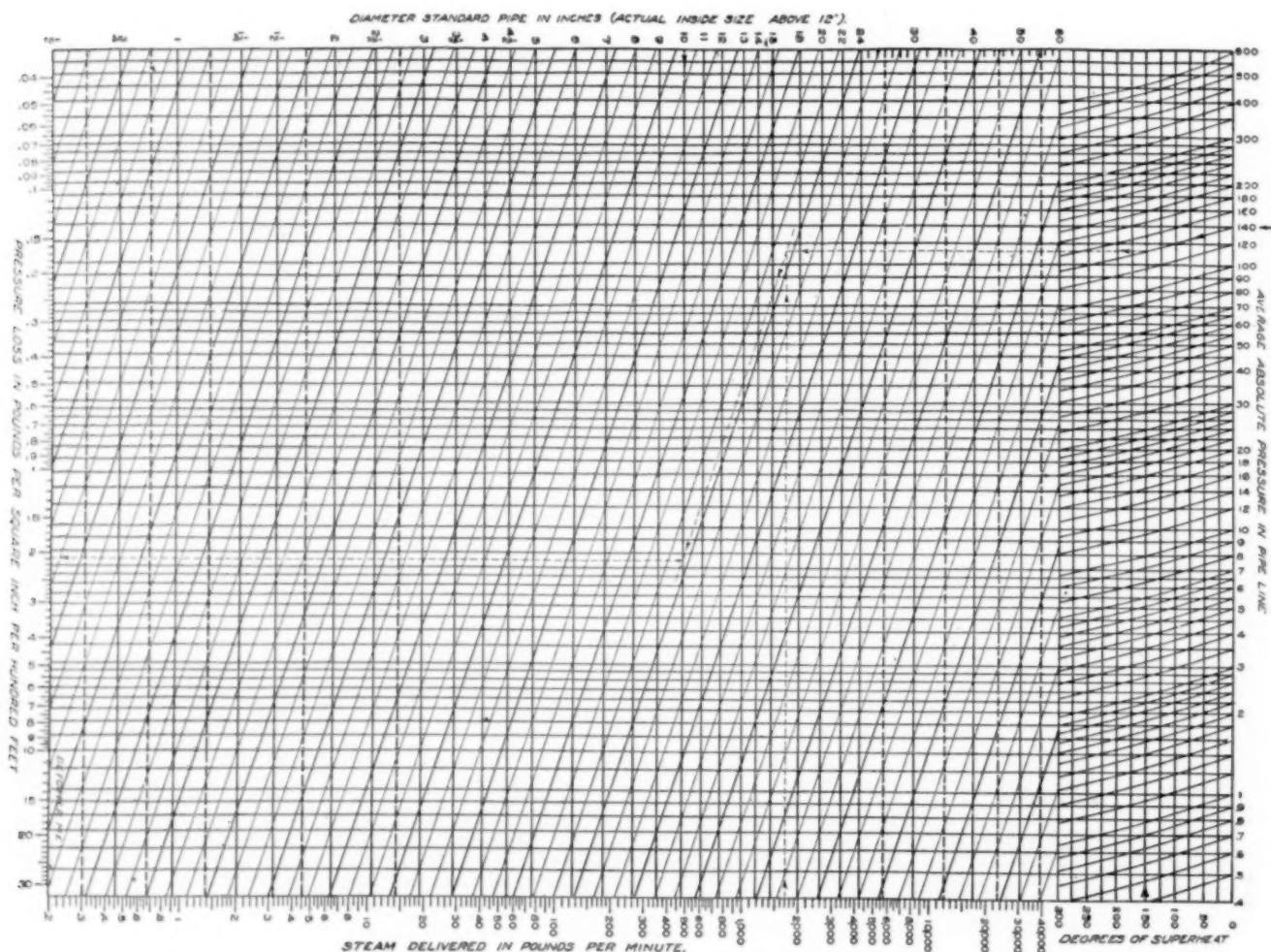
Formula Used: $L_e = 53.75rd^{1.00}$

Pipe Nominal Size, in.	Actual Inside Diameter, in.	Gate Valve	Long-Sweep El. or Standard Tee	Medium-Sweep Elbow or Tee Reduced in Size $\frac{1}{2}$	Standard Elbow or Tee Reduced in Size $\frac{1}{2}$	Angle Valve	Close Return Bend	Tee Through Side Outlet	Globe Valve
Factor of Resistance...		0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
$\frac{1}{8}$	0.662	0.335	0.442	0.56	0.89	1.20	1.34	1.79	2.68
$\frac{1}{4}$	0.824	0.475	0.627	0.79	1.27	1.71	1.90	2.52	3.80
$\frac{3}{8}$	1.049	0.640	0.844	1.07	1.72	2.30	2.56	3.40	5.12
$\frac{1}{2}$	1.38	0.902	1.19	1.51	2.42	3.24	3.61	4.80	7.22
$\frac{3}{4}$	1.61	1.09	1.43	1.83	2.92	3.92	4.36	5.79	8.72
1	2.06	1.49	1.96	2.50	3.99	5.36	5.96	7.92	11.92
1 1/2	2.46	1.86	2.46	3.13	5.00	6.72	7.47	9.93	14.94
2	3.06	2.46	3.25	4.11	6.66	8.87	9.86	13.11	19.72
2 1/2	3.54	2.92	3.80	4.91	7.84	10.53	11.70	15.56	23.40
3	4.026	3.44	4.53	5.77	9.22	12.37	13.70	18.28	27.50
3 1/2	4.506	3.95	5.20	6.63	10.60	14.22	15.80	21.01	31.60
4	5.047	4.57	6.00	7.68	12.20	16.47	18.30	24.33	36.60
4 1/2	5.506	5.12	7.55	9.61	15.30	20.61	22.90	30.45	45.80
5	6.024	6.90	9.10	11.59	18.50	24.84	27.60	36.70	55.20
6	7.981	8.10	10.67	13.60	21.70	29.16	32.40	43.09	64.80
8	10.020	10.70	14.10	17.97	28.70	38.52	42.80	56.92	85.60
10	12.090	12.50	17.80	22.68	36.20	48.60	54.00	71.82	108.00

CONDUITS CARRYING VAPORS OR GAS

Formula Used: $L_e = 43.7rd^{1.00}$

Factor of Resistance...	0.25	0.33	0.42	0.67	0.90	1.00	1.33	2.00
$\frac{1}{8}$	0.622	0.031	0.41	0.52	0.84	1.12	1.25	1.66
$\frac{1}{4}$	0.824	0.044	0.57	0.73	1.17	1.57	1.75	2.33
$\frac{3}{8}$	1.049	0.057	0.77	0.98	1.57	2.11	2.34	3.11
$\frac{1}{2}$	1.380	0.082	1.07	1.37	2.19	2.94	3.27	4.35
$\frac{3}{4}$	1.610	0.098	1.29	1.64	2.63	3.52	3.92	5.21
1	2.067	1.32	1.74	2.23	3.55	4.77	5.30	7.05
1 1/2	2.469	1.64	2.16	2.75	4.39	5.91	6.56	8.71
2	3.068	2.13	2.81	3.59	5.72	7.69	8.54	11.40
2 1/2	3.548	2.53	3.34	4.26	6.80	9.10	10.13	13.50
3	4.026	2.96	3.90	4.97	7.94	10.65	11.84	15.75
3 1/2	4.506	3.27	4.45	5.66	9.05	12.14	13.50	17.95
4	5.047	3.88	5.11	6.42	10.40	13.95	15.51	20.60
4 1/2	5.506	4.81	6.35	8.09	12.90	17.35	19.27	25.60
5	6.024	5.75	7.59	9.66	15.40	20.70	23.02	30.60
6	7.023	6.70	8.85	11.20	17.90	24.10	26.80	35.60
8	9.981	8.75	11.54	14.70	23.40	31.50	35.00	46.60
10	12.02	10.90	14.40	18.35	29.30	39.30	43.70	58.10
12	12.09	10.90	14.40	18.35	29.30	39.30	43.70	58.10



GRAPHICAL SOLUTION OF BABCOCK'S FORMULA FOR FLOW OF STEAM IN PIPE LINES

Determination of Atmospheric Impurities—II

A Description of the Nature of Atmospheric Impurities With Special Reference to Salt Lake City, Utah,
Conditions—Methods and Apparatus Used for Their Determination—Results
Obtained—Physical Character of the Solid Atmospheric Impurities*

BY OSBORN MONNETT

A SUMMARY of the results of atmospheric analyses of Salt Lake City, as described in Part I, showing concentration of solids, carbon dioxide and nitrous acid together with accompanying weather conditions is set down in Table I.

SOOT FALL STUDY

Twenty locations for the placing of soot fall jars were selected. During September, October and November earthenware butter crocks about 5 in. in diameter were used. The crocks were easily broken by rain water freezing in them and the glaze tended to chip off and contaminate the soot collected. Enameled ware pails 6.5 in. in diameter were then substituted. Care was taken to set the pails at a sufficient distance from stacks to avoid local contamination. At intervals of about one month clean pails were substituted for the exposed pails, which were taken back to the laboratory for weighing and analysis of the soot. Some trouble was experienced from the chipping of the enamel on the pails and it is believed that a copper vessel would be more suitable where freezing weather is experienced.

The soot was filtered from the water on a weighed ashless paper. After drying, the paper was weighed again and the gain in weight calculated to tons of deposit per square mile per annum.

The papers were then ignited and again weighed in order to determine the amount of combustible matter in the soot. The amount of soot collected was insufficient for further chemical analysis—e.g., determination of tar or composition of ash.

Table II shows the soot fall in Salt Lake City from Sept. 5, 1919, to April 20, 1920, calculated to tons per square mile per annum.

Interpretation of Results. The following general conclusions may be drawn:

1. Total solids and total combustible matter are low during the heating season—i.e., November to February.

2. The per cent of combustible matter in the deposit is, however, higher during the heating season, rising from 30 per cent to 40 per cent.

3. The amount of material deposited is highest in the center of the city and in the vicinity of the railroad yards, being about 200 tons in the residence district and probably 800 tons in the business district and railroad yards.

4. The per cent combustible matter is highest in the center of the city and in the vicinity of the railroad yards, being about 40 per cent, as against about 30 per cent for the residence district.

5. Average figures for the part of the city covered over the entire period are: Total solids, 349 tons per square mile per annum; combustible matter, 122 tons per square mile per annum; per cent combustible matter, 35. Average figures during the heating season are: Total solids, 250 tons per square mile per annum; combustible matter 95 tons per square mile per annum; per cent combustible matter, 39.

It is evident that a large part of the material caught in the soot fall jars is of non-fuel origin. The amount of solids in the jars seems to vary with the wind velocity, decreasing from November through February and then steadily rising until in April the amount is over three times as large as in December, January or February. Microscopic examination of the precipitates collected during September, October, March and April shows large quantities of soil and organic matter, while the solids collected during November, December and January are practically all of fuel origin. This is borne out by the figures for percentage of combustible matter in the solids. This averages about 30 during September, October, March and April and rises to 40 during December and January.

Analyses were made of the water in soot fall jars for the periods Dec. 18, 1919, to Jan. 24, 1920, and Jan. 24

TABLE I. SUMMARY OF ATMOSPHERIC ANALYSES

Date	Location	Av. Temp.	—Wind—		Rel. Humid.	—Conc., Mg. per Cu. In.—			
			Vel.	Dir.		Vol. Air Filtered	Soot	CO ₂	HNO ₂
Nov. 18	University.....	44	4	N.W.	64	10.5	0.9	285	0.013
Nov. 24	3d W. 1 No.....	40	5	SW-NW	54	7.1	0.4	385	0.009
Nov. 25	8 So. Main.....	33	5	N.W.	73	6.5	0.5	400	0.0018
Nov. 28	344 S. State.....	37	7	N.W.	63	10.1	1.0	340	0.0107
Dec. 3	Boston Bld.....	48	6½	N.W.	47	5.4	0.9	430	0.0125
Dec. 4	Boston Bld.....	54	5	SE-NW	56	12.6	1.2	385	0.0163
Dec. 10	Boston Bld.....	38	20	SE-SW	49	15.0	0.1	276	0.0052
Dec. 12	344 S. State.....	17	9	N.W.	78	7.3	0.7	315	0.011
Dec. 16	2 S. & 5 E.....	21	3	SE-W	71	8.6	1.9	270	.....
Dec. 17	5 W. & 1 No.....	23	4	SW-NW	75	9.1	1.1	415	0.0118
Dec. 22	344 S. State.....	28	4	N.W.	72	7.1	2.3	330	0.0322
Dec. 26	530 W. 1 No.....	35	7	SE-NW	61	10.1	1.2	380	0.0132
Dec. 29	164 S. 9th E.....	17	4	N.W.	96	10.8	1.8	380	.....
Dec. 30	1650 S. State.....	18	5	N.W.	94	11.3	0.9	360	0.009
Jan. 2	43 W. 4th So.....	29	4	SE-NW	70	11.1	1.4	340	0.012
Jan. 16	344 S. State.....	36	4	S-SE	63	3.5	2.5	380	.....
Jan. 18	164 S. 9th E.....	40	4	W-NW	55	12.1	1.7	.....	.....
Jan. 27	344 S. State.....	49	4	SW-W	52	10.6	0.9	.....	.....
Jan. 28	580 W. 1 No.....	45	3	N.W.	59	13.4	1.5	.....	.....
Jan. 29	344 S. State.....	41	3	NW-SE	68	10.4	1.7	.....	.....
Jan. 30	580 W. 1 No.....	43	4	N.W.	77	9.1	1.3	.....	.....
Feb. 11	344 S. State.....	37	4	W-NW	51	10.0	0.8	.....	.....
Feb. 12	344 S. State.....	44	4	S.W.	37	9.6	1.0	.....	.....
Feb. 16	344 S. State.....	44	8	N.W.	54	11.1	0.9	.....	.....
Feb. 17	905 S. State.....	40	6	SW-NW	50	11.7	0.2	.....	.....
Feb. 18	344 S. State.....	48	5	SW-NW	30	8.8	1.1	.....	.....
Feb. 19	164 S. 9th E.....	50	15	SE-SW	26	9.3	0.3	.....	.....
Feb. 26	344 S. State.....	40	7	S.W.	49	10.1	0.5	.....	.....
Mar. 5	344 S. State.....	40	12	N.W.	51	3.8	0.5	320	.....
Mar. 8	344 S. State.....	52	8	S.W.	34	6.7	0.7	270	.....
Mar. 12	Boston Bld.....	48	8	S.W.	37	6.3	0.1	270	.....
Mar. 16	344 S. State.....	42	10	S.E.	29	5.9	0.3	350	.....
Mar. 19	164 S. 9th E.....	41	8	N.W.	49	11.2	0.9	350	.....
Mar. 22	164 S. 9th E.....	47	17	S.W.	39	3.9	0.1	325	.....
Mar. 25	980 W. 2 So.....	50	22	S-SW	43	5.7	0.1	340	.....
Apr. 6	164 S. 9th E.....	48	4	SE-SW	54	15.0	0.7	340	.....
Apr. 7	1646 S. State.....	57	9	N.W.	56	8.2	0.2	285	.....
Apr. 8	905 S. State.....	50	11	N.W.	83	11.6	0.3	285	.....
Apr. 9	580 W. 1 No.....	60	19	S-SW	27	11.7	0.2	310	.....
Apr. 10	344 S. State.....	.....	.....	.....	.....	8.0	0.1	.....	.....

*For Part I see CHEM. & MET. ENG., vol. 23, No. 23, p. 1,117.

EDITOR'S NOTE: This is a chapter of the smoke-abatement report made by the Bureau of Mines in June, 1920, on its work in Salt Lake City, where it had the co-operation of the city and State University authorities. Published by permission of the Director of the Bureau of Mines.

TABLE II. SOOT FALL IN SALT LAKE CITY, CALCULATED IN TONS PER SQUARE MILE PER ANNUM

Location	Sept. 5-Oct. 15			Oct. 15-Nov. 4			Nov. 4-Dec. 18			Dec. 18-Jan. 24			Jan. 24-Feb. 21			Feb. 21-Apr. 1			Apr. 1-Apr. 20			Average by Location		
	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible	Total Solids	Combustible Matter	Per Cent Combustible
1 756 N. 8 West.....	189			86			124	37	30	113	51	45	104	53	51	286	72	25	243	59	24	172	46	27
2 3 N. and Grant.....	272	95	35				173			161	73	45	160	72	45	252	83	33				218	82	38
3 914 W. 2 South.....	841			145			863	380	44	627	275	43				1,053	263	25	450	122	27	798	283	35
4 558 S. 4 West.....	446			371			735	286	39	671	302	45	817	335	41	900	315	35	829	315	38	780	300	38
5 3d W. and 1st N.....				379			849	517	61	981	470	48	362	145	40	1,362	667	49	1,582	602	38	1,015	498	49
6 Main and N. T.....	666	220	31	285						251	98	39				189	51	27	1,474	354	24	567	155	27
7 Federal Bldg.....	606												1,800	540	30	1,800	540	30	7,163	6,750	94	3,020	1,960	65
8 8th S. and Main.....	351						306	77	25	75	53	71										200	66	33
9 1450 S. 4th E.....	415			110			100	14	14	86	14	32	94	30	32	330	106	32	378	136	26	184	53	29
10 3d S. and 3d E.....				230	69	30				15	3	20	368	110	30							172	51	30
11 89 D St.....				189			156	34	22	93	32	34	224	54	24	413	95	23				222	54	24
13 425 E St.....	336			102			122	16	13	170	39	23	80			295	35	12	1,042	125	12	308	42	14
14 418 K St.....	137						118	26	22	51			75	8	11	621	248	40	592	102	17	308	104	34
15 721 2nd Ave.....	221	58	26	196	58	30	133			103	58	57	137	33	24	490	284	58	533	165	31	275	116	42
16 735 S. 9th E.....	190	44	23	129	35	27	76	17	22	113	36	32	106	17	16	266			407	94	23	152	37	24
17 318 S. 9 E.....	73			148			82	15	18	63	21	33	87	14	16	248	57	23	269	54	20	122	31	25
18 859 Emerson.....	152			152			213	42	20	92	39	42	142	17	12	348	69	20	559	106	19	248	52	21
19 University of U.....							580	128	22										248	136	55	467	131	28
20 120 H St.....				214	64	30	188	62	33	15	8	54	229	80	35	399	112	28	1,101	243	32	302	86	29
Average by months.....	349	104	30	195	57	29	303	117	39	226	98	43	213	74	33	513	175	34	727	191	26	349	122	35

to Feb. 21, 1920. These are set down in Table III. Snow samples collected Dec. 15, 1919, at several locations in the city were also analyzed. The results have been set down in Table IV.

PHYSICAL CHARACTER OF THE SOLID MATTER ENCOUNTERED IN SMOKE ABATEMENT STUDY AS SEEN UNDER THE MICROSCOPE

The solid material collected in soot fall jars, which were placed in various parts of the city, was examined microscopically in order to determine the physical condition of the individual particles. Since this material had been exposed to the elements during the period of deposition, the jars contained more or less water when collected which necessitated filtering and drying. During the filtering and consequent drying, the fine particles of soot and ash became so thoroughly imbedded in the mesh

tain clinker or fused material, coke, ash, soot, woody fiber, dust or siliceous material, organic matter and lint.

Clinker. The material designated as clinker comprises that portion of the solid matter which shows evidence of having been fused. It appears in varying amounts in all the soot fall jars and presents some interesting features when viewed under the microscope. There are three types of the fused material: (1) the

TABLE IV. IMPURITIES IN SNOW

Snow collected Dec. 15, 1919; from 1 sq. ft. area to a depth of about 1 in. This gave about 2.3 liters of snow, which melted to about 0.6 liter of water. Snow on ground seven days.

Jar No.	Location	Tons per Square Mile per Annum				
		Solids	HNO ₃	NH ₃	Cl ₂	H ₂ SO ₄
1	756 N. 8th West.....	88	0.69	...	...	...
3	914 W. 2d South.....	267	0.69	1.18	0.52	...
4	558 S. 4th West.....	450	31.85	15.00	1.17	...
5	3d W. and 1st North.....	2,100	21.65	1.18	...	134
14	418 K St.....	40	0.74	6.00	...	...

hollow type, (2) the globular solid type, and (3) the irregular shaped, slaglike mass type.

1. The hollow particles are black in color and have a somewhat rounded irregular form or shell. Owing to the thin shell, they are quite easily broken, especially so since the shell is quite brittle. In the case of the larger particles these shells have one or more openings which, from their appearance, have been caused by the sudden release of gas from within while the slag or clinker was in a somewhat semi-molten or viscous condition.

2. The globular or glassy appearing particles range in color from that of a clear glass, through pearly white and various shades of brown to a slag black. They are of all sizes and all are apparently solid.

3. The small particles of irregular shaped clinker present no particular features of interest, although it may be stated that many of the black slag-like grains are attracted by the magnet, due to the presence of a small amount of iron.

Coke. The particles under this head are not true coke, although they resemble it in appearance. They are partly consumed particles of coal which have been carried up and out of the flues by the hot gases before the process of combustion has been completed. Shaking the grates and raking the furnace fires would tend to dislodge material of this nature together with quantities of ash.

TABLE III. RAINWATER ANALYSES

Water Collected in Soot Fall Jars. Calculated in Tons per Square Mile per Annum

Dec. 18, 1919, to Jan. 24, 1920						
Jar No.	Location	HNO ₃	NH ₃	Cl ₂	H ₂ SO ₄	
2	3d N. and Grant Av.....	161	0.09	1.54	trace	24
3	914 W. 2d South.....	630	0.79	1.56	0.07	74
4	558 S. 4th West.....	670	1.08	32.60	0.05	104
5	3d W. and 1st North.....	980	0.53	6.15	0.04	138
6	Main and N. T.....	250	0.05	1.36	0.28	00
8	8th S. and Main.....	75	0.19	1.74	0.03	31
14	418 K St.....	50	0.07	2.43	0.26	00
Jan. 24, 1920, to Feb. 21, 1920						
2	3d N. and Grant Av.....	160	0.05	2.23	trace	..
4	558 S. 4th West.....	820	0.11	5.20	trace	..
5	3d W. and 1st North.....	360	0.09	0.79	...	..
14	418 K St.....	75	0.06	0.62	...	..

of the filter paper that only the coarser granular matter was available for microscopic examination. This coarse material was examined by means of the binocular microscope, the finer material being disregarded for the time, separate samples composed entirely of soot and ash being collected separately. It may be stated in a general way that the solid material collected in the soot fall jars is more or less similar in regard to the physical characteristics of the component particles. Practically the same class of solids was found in the jars from the different localities, although there was a noticeable difference in the amounts of the several classes of constituent grains and their size. When examined under the microscope the contents of the jars were found to con-

Soot and Ash. As before stated, the wetting received during exposure to the weather made it a difficult matter to examine the soot and ash content of the soot fall jars. The presence of these two constituents was apparent, however, since the rains and snow had washed them into the pores of the coke and irregular shaped particles where they could be distinguished under the microscope.

Woody Fiber and Dust. Salt Lake City has no wood block paving and the woody material found in the soot jars consisted largely of the debris of various types of vegetable matter such as grass, straw and dried vegetation in general, together with partly burned splinters of wood and charcoal. Siliceous particles and other mineral grains were noted under the microscope, although they comprise but a relatively small portion of the solid matter found in the jars. The presence of this material in the jars can be attributed to the action of wind and air currents which have carried it upward into the atmosphere, whence it settled. The amount of this material in the air diminishes to practically nothing during the winter months, when the ground is covered with snow for the greater part of the time. The charred wood and charcoal are of stove and furnace origin and small quantities of these two constituents are present throughout the smoky season.

Organic Matter. The organic matter in the samples consisted chiefly of the remains of dead insects, some of which had undoubtedly met their end in the jars, while in other cases their bodies had been deposited there through the agency of wind and air currents. The presence of this type of material is mentioned only as a matter of interest and merely shows that the air we breathe is laden to some extent with solids of many varieties.

JAR CONTENTS FROM DIFFERENT LOCALITIES

For the purpose of comparison, the solid matter collected may be considered under three heads: (1) Railroad yards and warehouse district, (2) business district and (3) residence district. The quantitative comparison, by weight, of the samples collected in the different localities has already been discussed.

The particles from the railroad yards and warehouse districts are as a rule larger in size than from either of the other districts and apparently contain a greater amount of unconsumed fuel or coke-like material. It is also noticeable that the relative amount of wood fiber, in

the form of straw and grain husks, is greater than in the downtown and residence sections. While the bomb-like and slaggy clinker material occurs in the jars from all three localities, the particles from the railroad district are larger in size than in the residential section. The greater size of the individual grains, together with the predominance of partially consumed material in the downtown and warehouse districts, constitutes one of the most noticeable differences in the soot fall samples from the three districts. There is apparently less ash in the warehouse and railroad samples than in the samples from the downtown and residence portions of the city.

SOLID IMPURITIES SUSPENDED IN THE ATMOSPHERE

The solid particles described represent the material which is of such size and weight that it does not remain suspended in the atmosphere for any great length of time. It settles out within a comparatively short interval after emanation from stacks and chimneys. There is another type of solid which has not yet been

TABLE V. SOOT FALL IN SALT LAKE CITY COMPARED TO THAT IN OTHER CITIES

	Min.	Max.	Mean	Coal Consumption
Leeds.....	25	539	220	1,500,000
London.....	58	426	260	16,000,000
Glasgow.....			1,325	3,250,000
Hamburg.....	345	690		3,000,000
Pittsburgh.....	595	1,807		
Salt Lake City.....	15	980	250	510,000

considered and which constitutes a considerable portion of the atmospheric pollution during the winter months. Soot or carbon particles in the air form a very annoying form of nuisance. They are present at practically all times when the atmosphere is smoke laden and exist in all sizes from the large flakes which are visible to the naked eye to particles which are only resolved under a high-power microscope. Many of these soot particles are of sufficient size and weight to settle in a comparatively short time after their introduction into the atmosphere. Others which are of microscopic size will remain suspended almost indefinitely, depending on size, humidity, air currents, etc. Samples of this finely divided soot were obtained by the use of the Hill Dust Counter, and when examined under the microscope show the presence of many particles of carbon or soot which range from 25 microns (1 micron = one one-thousandth of a millimeter) in size down to particles which are just barely visible at high magnifications.

TABLE VI. ATMOSPHERIC IMPURITIES IN OTHER CITIES COMPARED WITH SALT LAKE CITY

City	Population	Coal Consumption, Tons per Annum	Solid Impurities			Gaseous Impurities						Ammonia	
			No. Particles per Cu. C.	Milligrams per Cubic Meter	Soot Fall Tons per Sq. Mile per Annum	Total Sulphur Acids		Chlorine		Nitrous Acid Milligrams per Cu. Meter	Milligrams per Cu. Meter	Tons per Sq. Mile per Annum	Tons per Sq. Mile per Annum
						Carbon Dioxide Parts per Million	Sulphur Dioxide Parts per Million	Milligrams per Cu. Meter	Tons per Sq. Mile per Annum	Milligrams per Cu. Meter	Tons per Sq. Mile per Annum		
Manchester.....	725,000	3,000,000			240	311-403							
Leeds.....		1,500,000	32,000		25-539								
			228,000										
London.....		16,000,000	400,000		58-426	345-439	0.0-6.0		69		26		51
Glasgow.....		3,250,000	228,000		1,325	336-502							
Berlin.....	2,100,000	3,150,000		0.06-0.31		307-402	0.5-0.7		1.3-3.0				
Hamburg.....	1,000,000	3,000,000		0.03-0.15	345-690			0.062-0.512					
Paris.....	2,700,000					243-422							
Cleveland.....	500,000	2,800,000		1.5-39.9		352-452		33.02					
Chicago.....	2,185,000	17,500,000		0.321-1.958		317-374		0.069	0.0253	0.00153	0.0055		
						Max. 472		1.104	0.01576	0.01576	0.0224		
Pittsburgh.....					595-1807								
Salt Lake City.....	140,000	510,000		0.0-2.5	15-980	270-430	0.0-0.8	0.1	0.002-0.034	0.1	0.009-0.032	0.001-0.080	7
					Av. 220	Av. 335	Av. 0.1						

It has been shown by investigators of mine dust that comparatively few particles of dust larger than 10 microns reach the lungs and the same condition probably obtains with regard to the soot particles. That a considerable amount of soot particles are taken into the lungs is evidenced by the examination of the lung tissue of deceased persons who had lived in a smoke-polluted atmosphere. Sections of lung tissue of such persons show clearly the presence of particles of carbon when examined under the microscope. The amount of the carbon particles in the lung tissue depends largely on the length of time which is spent in a smoke-laden atmosphere, but it is certainly a fact that long residence in a smoky city results in the deposit of an appreciable amount of carbon in the lungs.

COMPARISON OF ATMOSPHERIC POLLUTION OF SALT LAKE CITY WITH THAT OF OTHER CITIES

Data for other cities are somewhat scanty and are not always expressed in units which admit of comparison with data obtained in Salt Lake City. The Chicago Smoke Abatement Commission¹ made a very thorough review of the literature on the subject of atmospheric pollution. The data here given have been taken from the above report.

Soot Fall. Comparison with results obtained in other cities is not easy owing to the difficulty in accurately estimating the composition of material collected in the soot fall jars. Obviously sand, soil and organic matter should be considered separately from that part of the solids which is of fuel origin. Except by laborious microscopic methods it is difficult to distinguish between coal ash and other mineral matter or between carbon from coal and that from organic matter.

In the winter in Salt Lake, with low prevailing winds and the ground covered with snow, it is safe to assume that the majority of the soot fall is of fuel origin. It is evidently these winter-time figures rather than the abnormally high spring-time figures which should be used in comparison with other cities where in general the smoke nuisance is not confined to one season as in Salt Lake. Such a comparison is made in Table V.

The mean soot fall for Salt Lake is as low as for any of the cities in the table. The maximum soot fall is higher than any with the exception of Pittsburgh and Glasgow. In comparison with its coal consumption Salt Lake shows a higher soot fall than any of the cities in the table, even if the smaller area be taken into account.

Other Impurities. In Table VI a summary of all data comparable with those obtained in Salt Lake City has been set down.

The table shows the concentration of solid matter in milligrams per cubic meter to be higher in the winter than for any other city with the exception of Cleveland.

Carbon dioxide does not differ much from the amount found in other cities.

Sulphur dioxide in Salt Lake is lower than in the other cities.

Sulphur acids in rain water and snow are about equal in amount to that found in Leeds and London.

Chlorine is low in comparison.

Nitrous acid is lower than in Chicago.

The maximum ammonia concentration is higher than in Chicago. Figured in tons per square mile per annum, the ammonia is about one-seventh that of London.

SUMMARY

A study of the character and amount of atmospheric impurities in the air of Salt Lake City has been made. This has included: 1. Estimation of the solids and gases present, including sulphur dioxide or smelter gas. 2. A soot fall study in which the amount of material settling at different locations has been measured and analyzed by months.

The results of this study show:

1. The concentration of solids in the atmosphere varies from less than 0.1 mg. per cu.m. to 2.5 mg. per cu.m. The highest concentrations occur during the heating season and in the business district. In the heating season these solids are practically all of fuel origin.

2. The total soot fall during the heating season averages about 250 tons per square mile per annum; 95 tons or about 40 per cent of this material is combustible matter.

3. Sulphur dioxide determinations showed an average concentration of 0.15 part per million during December and January and 0.01 part per million during March. The gas present is due to combustion of coal in the city. It is a negligible factor in the smoke nuisance.

4. The smoke concentration and soot fall is as high as that observed in cities consuming five to ten times as much coal yearly.

5. The results obtained afford a basis to judge the improvement made in future years.

Notes on the German Chemical Industry

Our correspondent in Germany reports on conditions in that country as follows:

The German dye trust, consisting of eight of the largest German chemical works, like the Badische Anilin- und Soda-Fabrik, Farbenfabrik Bayer & Co., Farbwerke vom. Meister, Lucius & Brüning, have decided to extend the life of its agreement, which was to run to Dec. 31, 1965, for another thirty-five years—i.e., up to the end of this century. Provision is thus made for a continuation of the present conditions for eighty years ahead. The firms in this trust have further decided to form a company with a capital of 500,000,000 marks to exploit the nitrogen industry. This company will take over the two nitrogen works in Oppau and Merseburg belonging to the Badische Anilin- und Soda-Fabrik. It is reported that the works at Oppau are fairly well employed. Of the normal number of workmen—8,400—6,000 are fully employed, while the remaining 2,400 will get full employment in the near future.

During the war the distribution of the total soda and potash production of Germany has been regulated officially by one of the so-called war companies. This state of affairs has now been terminated and the distribution has been given over to the trade again. This new step does not include the export and import, which are still tied to official licences.

The export of soda and caustic soda is still embargoed.

The demand for sal ammoniac has slackened considerably. The prices, which are regulated by the government, remain unchanged.

The demand for tar products is very strong. The demand for pitch, which was lifeless for a time, has now revived. Orders for benzene are still coming in with great pressure and can only partly be executed. The demand for cumaron has slackened and prices are going down.

¹Report of the Chicago Association of Commerce Committee of Investigation on Smoke Abatement and Electrification of Railway Terminals, W. F. M. Goss, chief engineer. Rand, McNally & Co., Chicago, 1915, pp. 40-48.

Legal Notes

BY WELLINGTON GUSTIN

Directors Held Liable for Paying Unwarranted Dividends

The United States District Court, Eastern District of Pennsylvania, has decreed the directors of the American Galvanizing Co. to be personally liable for the debts of the insolvent corporation. Suit was brought against them by the United States Smelting Co. with the Picher Lead Co., Canada Metal Co. and Adam Hope & Co. as interveners. The case was before the same court in 1917 on a motion to dismiss the bill. The motion was dismissed and now a decree is entered against the directors. (261 Fed., 547.)

The American Galvanizing Co. had been in existence about nineteen months and was yet to declare its first dividend, when the directors declared a 500 per cent dividend. Almost immediately afterward the company by the act of these same directors was declared to be insolvent. It appears the company had entered into a number of contracts which began to mature and ripen into debt obligations payable about the time or shortly after the dividend was declared. It had outstanding contracts for the purchase of spelter, the raw material which it used in its manufacturing processes. These contracts proved the undoing of the company, as the drop in the price of spelter entailed a destructive loss upon it.

The company had done prosperous business and was in a prosperous condition at the time of the declaration and payment of the dividend. Including the contributions to its capital it had net assets valued at \$71,134.99, and a surplus applicable to the payment of dividends of \$58,940.85. Its capital stock was \$10,000. It was contended by the directors that at the time the dividend was declared there was not only nothing to indicate the imminence of a loss, but, on the contrary, much to expect in the way of profit on its spelter contracts, because the spelter market was trending upward at the time. However, the court found that the market at the dividend date was so feverish and fluctuating and the general conditions such that there could not be said to be any stable market, and difficulty of securing supplies was so great that there was uncertainty as to future market conditions and an even greater uncertainty as to the manufacturing business.

On the date of the dividend the matured payable debts of the company did not exceed \$2,200, but at the time of bankruptcy, a few months afterward, the total was many thousands, existing in the form of obligations resting upon executory contracts in the form of purchases of spelter for future delivery.

The court said that if there be actual fraud in the declaring of the dividend, then the statute of Pennsylvania making directors liable for the debts of the corporation if they declare and pay a dividend when the corporation is insolvent, or the payment of which renders it insolvent, need not be resorted to. The statute extends to cases beyond those of actual fraud. The measure of responsibility visited upon directors can be more readily sensed than expressed in a formulated rule

of conduct. Because this is true, said the court, no honest director need be troubled with doubts whether he should favor or protest the declaration of a dividend. "No board of directors by the declaration of a dividend insures the solvency of the corporation. Such directors are held in the discharge of their duties only to the standard of the bona fide exercise of their best judgments."

There was no finding of fraud in the case, but only of facts upon which the law visits upon the directors a legal liability to pay the company's indebtedness.

The Ornstein Process of Chlorinating Water Upheld in Federal Court

A highly beneficial chemical process, as regards the public, is discussed in a patent suit of the Electro Bleaching Gas Co. against William G. Miller and another in the United States District Court at Kansas City, Mo. The Electro company is the assignee of George Ornstein, the inventor of process patent 1,142,361, for antisepticizing water. The invention "comprises a method wherein chlorine in determined amounts is uniformly distributed through and absorbed by a minor body of water flowing as a continuous current, and said minor body is then uniformly distributed through a major body of water, also flowing as a continuous current, all said operations being conducted without pause sufficient to allow disappearance of any substantial amount of said chlorine as free chlorine prior to exercising its antiseptic action."

DETAILS OF THE PATENTED PROCESS

It is said that the apparatus by which this process is made operative comprises an absorption tower, through which the minor flow of water passes downward to absorb an upwardly moving current of chlorine gas. The chlorine is supplied from a tank of compressed and liquefied chlorine gas, from which a pipe leads into the lower part of the tower. The tank is provided with a shut-off valve, and the supply pipe with a pressure-reducing valve and a regulating valve. Water is supplied to the tower from any suitable source, giving a substantially constant head through a pipe which leads into the top of the tower, and is provided with a shut-off valve and a regulating valve. The water-supply pipe is also provided with means for measuring the water flowing through it to the tower. For this purpose a suitable meter for indicating the quantity of water which has passed through may be used. The chlorinated water from the tower is discharged through a pipe to be united with the body of flowing water to be treated. The minor flow of water, after being chlorinated in the tower, is discharged directly into the water to be treated.

The absorption tower is formed of a vertically set shell of earthenware or other suitable material resistant to chlorine, filled, or substantially filled, with broken stone, coke or other suitable distributing material, adopted to film out the water and cause it to present an extended area of surface for contact with the ascending current of gas. The chlorine admitted to the minor flow of water is measured in determined proportion to the amount of water to be treated, but not necessarily with exactness in proportion to the minor flow. By this method a better and more effective solution is obtained, and better diffusion and distribution in the water to be treated, resulting in more complete and satisfactory sterilization of the water to be treated, less waste and

loss of chlorine, and less injury to the metallic part of the structure through the destructive action of the chlorine than can be accomplished by direct methods of introduction of the chlorine into the main body of the water to be treated; also excessive chlorination, with its attendant disagreeable features, is avoided.

The two main elements of the invention are the minor continuous flow of water and the regulation of the current of chlorine gas introduced therein in an amount predetermined according to the volume of water to be treated. The first of these employs as its vehicle the absorption tower with its appurtenances; the second element the pressure-reducing and regulating valves, with their attendant mechanism commonly called "regulator."

The defendants in the case manufacture the "Miller chlorine gas pressure regulator." It appears that the Miller regulator had been used by the city of Chicago and elsewhere to replace the corresponding part in the Electro company's apparatus. Contributory infringement of the process was predicated upon this use, charging the process of antisepticizing water which constitutes the invention by substitution of the vital element performed by the regulator.

DEFENSES TO THE SUIT

There were two defenses to the suit: (1) That the alleged improvements set forth in the said letters patent were not novel and patentable when produced by Ornstein, and the patent is accordingly invalid. (2) Even though the patent be upheld, respondents are protected by the right of use, enjoyment, repair and improvement in the purchasers of the apparatus.

NO ANTICIPATION, SAYS COURT

The first defense rested on an earlier patent by Darnell, No. 1,007,647, which was claimed to anticipate Ornstein's process and thereby rob the latter of novelty necessary to invention. The Darnell patent does deal with sterilization of water by treating with chlorine gas. But the court found that it deals with the direct communication of the chlorine to the body of water to be purified as distinguished from the indirect method by means of a minor flow, which is the distinctive achievement and advance accomplished by the Ornstein process. The court found further that the indirect method was both disclaimed and discredited in the Darnell patent, which says:

"The chlorinated lime or soda, or the chlorine gas, has usually been mixed with a certain quantity of water, and determined amounts of this chlorinated water have been introduced into the effluvia to be disinfected. This is not an efficient method of using chlorine, because in the process of fluid sterilization by chlorine the principal disinfecting agent is not the chlorine itself but the oxygen liberated from water by the action of chlorine on the water. . . . When, therefore, chlorinated lime, chlorinated soda or chlorine gas is admixed with a quantity of water and this water is afterward used to disinfect or purify large quantities of other water a great loss of efficiency is the result."

MERE REFERENCE TO INDIRECT CHLORINATION DISCLOSES NO PROCESS

The court said the mere reference to indirect chlorination, without description and coupled with the declaration that such a method is inefficient, discloses no process and cannot anticipate even by suggestion.

Darnell, in this very language, discloses that the vital principle of the Ornstein process remained unperceived. He says the chlorine gas had usually been mixed with a certain quantity of water and determined amounts of this chlorinated water had been introduced into the body to be disinfected. In the methods with which he had been familiar, if any, says the court, it would appear that chlorine gas was admixed with a quantity of water and this water was afterward used to disinfect or purify. It had never occurred to those who were studying this problem and who were endeavoring to get successful and satisfactory distribution and conservation of the disinfecting property of the chlorine that a predetermined amount of chlorine, in exact proportion to the body to be purified, might be introduced into that body through the instrumentality of an active minor flow to the volume of which the amount of chlorine used need bear no fixed ratio.

The idea of chlorine in determined amounts being uniformly distributed through a major body of water by means of a minor body flowing as a continuous current and carrying the chlorine in solution had not yet been conceived, it was said. This was the pregnant contribution of Ornstein to this art. One witness in the case, Prof. Jackson, stated in substance that "Ornstein discovered a principle that accomplished a result which all scientific students of the art had been vainly seeking for years and which converted previous uniform failure into pronounced success. Since this invention, the Ornstein method is rapidly displacing other methods of water purification and has given abundant evidence of its utility." Therefore the court concluded that the patent was not anticipated in any prior patent or scientific publication, and that same is valid and of great value to the public.

CHARGE OF CONTRIBUTORY INFRINGEMENT UPHOLD

Passing to the charge of contributory infringement, the court stated the rule to be that "where a person furnishes a machine, composition of matter or other article which is particularly adapted to be used in performing a patented process and which the person furnishing the same intends shall be thus used, that person is liable, as a contributory infringer, for any infringement which afterward occurs in accordance with his intention."

The right of replacement, improvement, substitution or resupplying of an element of a patented apparatus depends entirely on whether the purpose is legitimate repair in the sense of restoration of worn-out or broken parts, said the court. And in this case, where the owners of a process patent for purifying water licensed its use by purchasers of the apparatus by which it was made operative, defendants, who sold a device to two of such purchasers, one of whom assisted in installing it in place of one of the parts of the patentee's apparatus, were held guilty of contributory infringement, where the substitution was not made because the part was worn out, and where the parts supplied were not small and trifling in character. Neither did the fact that the device was adapted to other uses, or was not identical in size or form with the corresponding element in complainant's machine, relieve from contributory infringement. Further it was said that where a patentee of a process licensed its use in connection with machines sold by him, the continued right to use it could not accompany any radical transformation of his machine by repairs.

Graphic Calculation of Neutralization of Caustic Liquors With CO₂

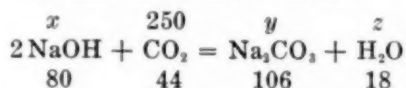
BY JOSEPH C. DITTMER

IN THE case for which the following method of calculations was originated, it was necessary to neutralize caustic soda liquor with carbon dioxide, the amount of liquor required for a given amount of gas being originally calculated by the foreman. As it was desired to have a simple method of calculation and one which the average process-man could work, the following graphical method was devised.

There are three factors capable of variation: the amount of carbon dioxide, the amount of caustic liquor, and the NaOH contents of the liquor. The amount of sodium hydroxide in the liquor is difficult to control, so that to keep its quantity constant is very inconvenient, but the amount of carbon dioxide is easily regulated, as it is usually taken from weighed cylinders. The amount of carbon dioxide will temporarily be fixed at 250 lb., and the two other factors will be permitted to vary according to conditions.

CAUSTIC LIQUOR EQUIVALENT TO 250 LB. OF CO₂

The chemical proportions of caustic and carbon dioxide may be taken from the reaction:

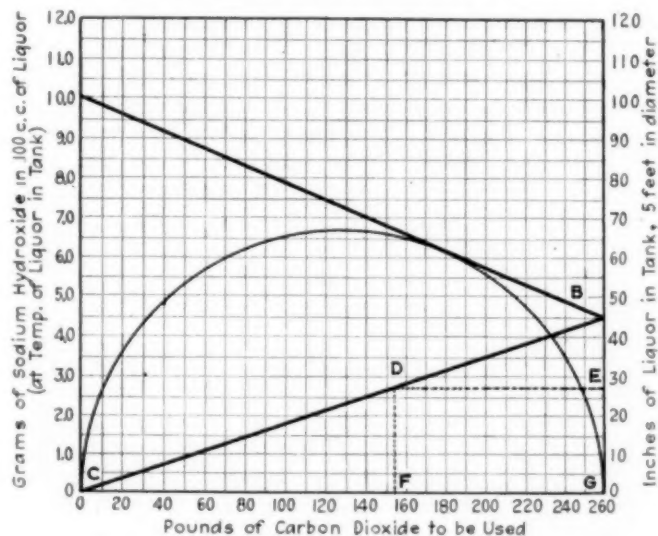


from which the amount, x , of NaOH which 250 lb. of CO₂ will neutralize, is calculated as follows:

$$80:44 = x:250 \text{ or}$$

$$x = (250)(80) \div 44 = 454.5 \text{ lb. of NaOH}$$

An analysis of caustic liquor gives 10.0 g. of NaOH in 100 c.c.; specific gravity 1.238.



The total amount of liquor needed to supply 454.5 lb. of NaOH is calculated from the proportion

$$10.0:123.8 = 454.5:x$$

$$\text{or } x = (454.5 \times 123.8) \div 10 = 5,626.71$$

As the tank measures 5 ft. in diameter, the volume of 1 in. in depth is:

$$0.7854 (5^2) \div 12 = 1.63625 \text{ cu.ft.}$$

The weight of this volume of liquor is:

$$(1.63625)(1.238)(62.5) = 126.6 \text{ lb.}$$

The number of inches of liquor needed is:

$$(454.5)(123.8) \div 10 (102.26)(1.238) = 44.45 \text{ in.}$$

of liquor from 5-ft. tank to neutralize 250 lb. of CO₂. Ten times 44.45 gives 444.5, which may be used as an equation constant for 250 lb. of CO₂, a 5-ft. diameter tank and a test sample of 100 c.c. at the temperature of the liquor in the tank. Dividing this constant by the grams of NaOH in 100 c.c. of the liquor, the inches of liquor required for 250 lb. of CO₂ is obtained.

For more or less than 250 lb. of CO₂—e.g., 150 lb.—the following relation holds:

$$44.45 (150) \div 250 = 26.67 \text{ in. in 5-ft. tank.}$$

GRAPHICAL SOLUTION

To find the number of inches of liquor from a 5-ft. tank corresponding to grams of NaOH per 100 c.c. graphically, a curve from which these values can be obtained is developed as follows:

Using a base line equal to the diameter of a circle with a radius equal to $\frac{1}{2} \sqrt{44.45}$, or 3.333 u., a perpendicular line is erected at each end, the vertical line at the left being used for plotting grams of NaOH (1 g. = $\frac{1}{2}$ u.), and the line at the right inches of liquor (10 in. of liquor = $\frac{1}{2}$ u.). Connecting each value in grams of NaOH with the resulting value in inches of liquor by a line, a half circle is determined to which these lines are tangent.

If x = grams of NaOH in 100 c.c. of liquor and y = number of inches of liquor for 250 lb. of CO₂, then $44.45 = xy$, as has been shown above.

For a value of x giving a line tangent to the curve and parallel to the base line: x , must equal y . As the values of y , as plotted, are ten times those of x , $y_1 = 10x$. Substituting this value in the equation $44.45 = xy$, gives $x_1 = 6.667$. As $y_1 = 10x$, $y_1 = 66.67$.

As the values of x are plotted according to the scale 1 g. = $\frac{1}{2}$ u., a half circle drawn with a diameter of 6.667 u. will give the curve to which lines connecting "grams of NaOH" and their corresponding number of inches of liquor are tangent.

The diameter of the circle, 6.667 u., is based on calculations using 250 lb. of CO₂ and is shown in the accompanying figure.

To determine graphically how many inches of liquor are required for more or less than 250 lb. of CO₂, connect the value of inches of liquor—e.g., point B on the accompanying diagram—with the origin (point C) by a line forming a right angle triangle. Erecting a perpendicular at the point of the amount of CO₂ to be used (e.g., 152 lb.) and extending it to meet the line BC at D, the length of this line DF or EG will give the amount of liquor required for the amount of gas taken (152 lb.).

This method of calculation can also be used when the amount of caustic liquor is constant and the amount of CO₂ is variable. For example, with liquor testing 10.0 g. NaOH per 100 c.c. and given 26.7 in. of liquor, draw the tangent AB and the line BC. From the value 26.7 in. of liquor extend a line to meet the line BC and where it intersects at D, drop a vertical line, DF. The value at F gives the amount of CO₂ needed to neutralize this amount of liquor.

Using chlorine as the neutralizing agent, 250 (70.96) \div 44 lb., or approximately 403 lb., would be required to do the equivalent amount of work. Putting the base line equal to 403 lb., it is a simple matter to calculate the amount of liquor required for a greater or lesser amount of this gas.

Static Notched-Bar Testing Machine

A NUMBER of notched-bar testing machines using the impact method for determining the quantitative measurement of the brittleness and ductility of steel and other metals have been designed. These differ largely in the method of applying the impact blow, of supporting the specimen, size of test-piece, shape and size of notch. The following is a description of the machine recently devised by J. C. W. Humphry.

In breaking a notched-bar test-piece there are two governing factors at each moment: the angle to which the specimen is bent and the resistance which it offers to the external bending force. If a notched-bar specimen is broken slowly by static pressure the work expended is comparable with that measured by a dynamic impact machine and is much more effective in distinguishing between brittle and ductile metals.

The test-piece *A* (Fig. 2) is gripped in the vise *B* so that the jaws of the vise are in line with the notch in the test-piece. The socket *C* is attached on the projecting end of the test-piece and is a reasonably close fit. A bending stress is applied to the test-piece by means of the winch *D* and the wire *E*. The inner end

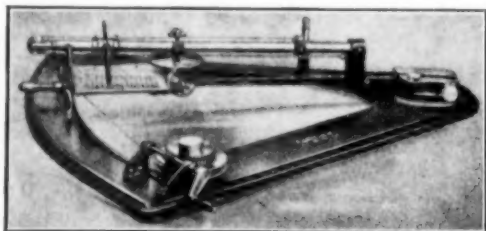


FIG. 1. STATIC NOTCHED-BAR TESTING MACHINE

of the spring bar is firmly fixed to the socket *C*. The outer end of the spring bar is supported by two rollers *G* and *G*₁. The socket *C* also carries a rigid bar *H*.

The deflection of the spring bar *F* is a measure of the bending moment applied to the test-piece. Since the rigid bar *H* is not subjected to any bending moment it will move through the same angle as the socket *C*, and this movement will therefore be a measure of the bending of the test-piece. The pen *J* slides upon the rigid bar *H*, its position being determined by the thin wires or cords *K* and *L* which are kept taut by a light spring *M*. One end of the wire *K* is attached to a post *N*

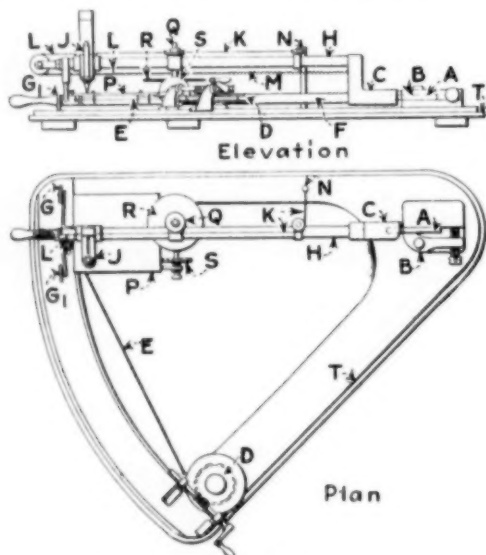


FIG. 2. ELEVATION AND PLAN

so that as the rigid bar *H* moves in consequence of the bending of the test-piece the wire *K* will draw the pen to the right. The point of the pen marks upon a calibrated chart *P* carried on the spring bar *F*; therefore if the test-piece offers no resistance whatever to bending force the pen would draw on the chart a

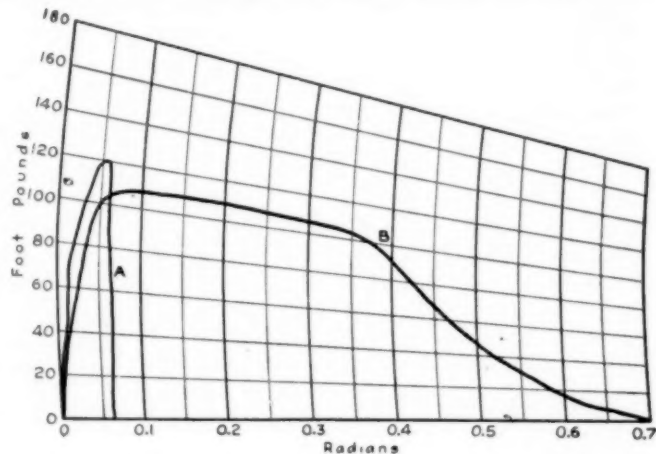


Fig. 3. A—Curve showing brittleness of nickel-chrome steel which has been made brittle by cooling from the tempering temperature. B—Curve showing ductility of a specimen of soft brass.

horizontal line, the length of which is proportional to the angle through which the test-piece is bent. However, as the test-piece does offer resistance to bending there will be resulting motion between the spring bar *F* and the rigid bar *H*.

Assuming the test-piece was infinitely rigid and did not bend at all under applied force, the pen would draw a vertical line on the chart, the height of this line representing the bending moment applied.

In actual practice, however, both of these effects are operative at the same time, with the result that with a brittle test-piece we get a curve represented in Fig. 3 by *A*, and with a ductile sample a curve shown by *B*.

The total energy absorbed in the breaking of the test-piece can, of course, be calculated easily from the diagram or graph. The machine is also fitted with an integrating device. This device is shown in Figs. 1 and 2. The wire *K* passes round a pulley *Q*. The pulley *Q* is attached to a spindle having at its lower end a friction disk *R* so that the bending of the test-piece, which results in the movement of the pen to the right, also results in a proportionate rotation of the friction disk *R*.

The lower face of the friction disk *R* rests upon the edge of the friction wheel, not shown. The spindle of the friction wheel is carried with the chart plate upon the spring bar *F*. When the bending moment is zero the friction wheel is at the center of the friction disk, but as bending moment is applied and there is therefore relative motion between the spring bar *F* and the rigid bar *H* the friction wheel travels toward the circumference of the friction disk and is consequently rotated. The rotation will be proportional to the product of the bending moment applied and the angle of bending of the test-piece, and this device will therefore integrate the total energy absorbed in breaking the test-piece. Mounted upon the outer end of the spindle which carries the friction wheel is an index disk *T*, which can be calibrated to read direct in foot-pounds.

The whole machine is mounted upon a rigid and heavy metal base *T* and is arranged for convenient and rapid operation by relatively unskilled users.

Recent Chemical & Metallurgical Patents

British Patents

Complete specifications of any British patent may be obtained by remitting 25c. to the Superintendent British Patent Office, Southampton Buildings, Chancery Lane, London, England.

Vulcanizing India Rubber.—India rubber in solution is vulcanized by the addition of sulphur and small quantities of nitrosobenzene or a similarly constituted nitroso-hydro-carbon of the cyclic series. In an example, 10 g. of rubber and 1 g. of sulphur are dissolved in 150 g. of carbon disulphide. There is added 0.6 g. of nitrosobenzene and the solution shaken. In about thirty minutes the solution sets to a jelly which on evaporation of the solvent yields vulcanized rubber, insoluble in the solvents for raw rubber. (Br. Pat. 146,734—1919; S. J. PEACHLEY, Davenport, Stockport, Sept. 22, 1920.)

Separating Dust From Gases.—A device for removal of dust from gases evolved in the roasting of ores consists of a chamber in which the current of gas passes at right angles through curtains consisting each of several parallel rows of chains which may be magnetized, the curtains being separated by spaces forming depositing chambers; the chains of consecutive rows of a curtain being disposed so as to split the current up as much as possible. The chains of a row may be fastened together, while the chains of the rows forming a curtain are connected to wires by which they may be shaken at intervals when no gas is passing. Dust falling to the bottom is carried outside the chamber by a screw conveyer. The chains of successive rows of a curtain may be disposed in echelon vertically or horizontally. (Br. Pat. 147,020—1919; MANUFACTURES DE PRODUITS CHIMIQUES DU NORD, Establissemments Kuhlmann, Paris, Sept. 22, 1920.)

Phenol Aldehyde Condensation Products.—In the production of insoluble infusible condensation products from phenols and formaldehyde or its polymers, the phenol is first condensed with the formaldehyde in the presence of an ammoniacal catalyst (ammonium carbonate or phenate) and the product is heated at 75 to 80 deg. C. until its viscosity has considerably increased; it is then mixed with an acid catalyst, particularly ethyl hydrogen sulphate, and converted into the final product at ordinary or only slightly raised temperature. The ethyl hydrogen sulphate may be added in alcohol solution and the product employed as a varnish. The product of the first stage of the process may be acetylated by treatment with acetic anhydride, and the acetylated product then treated with ethyl hydrogen sulphate. The acetylated products may be mixed with acetone solutions of cellulose acetate. (Br. Pat. 147,173—1919; J. FIHOL, Lyons, France, Sept. 29, 1920.)

Treating Cellulose-Containing Materials.—To avoid the deleterious effect of alkalis, acids and salts on cellulose fibers and also on the byproducts resin, tannin, carbohydrates, etc., due to the high temperatures obtained in the ordinary methods of treating wood and other cellulose-containing materials under pressure,

the pressure is produced externally and independently of the temperature used, by forcing or pumping air or other gas or suitable liquids, such as that used for treating wood, into the apparatus in which the material is being treated. Fifty atmospheres pressure or more may be used. The apparatus may be first exhausted, and alternate vacuum and pressure may be applied repeatedly. The process may be applied to reagents used for other purposes such as saccharification. (Br. Pat. 147,232—1919; ZELLSTOFFFABRIK WALDHOF, Mannheim, Germany, Sept. 29, 1920.)

Precipitating Bath for Artificial Threads.—A precipitating bath for artificial threads, etc., more particularly of viscose, consists of the crude mixture of carbohydrates, etc., obtained on hydrolyzing wood or other cellulose-containing materials with mineral acid; the acid in the bath may be partly or completely neutralized, and other reagents such as ammonium sulphate, sodium bisulphate, formic acid, lactic acid and alum, may be added. In an example, sawdust is kneaded with 80 per cent sulphuric acid, left to stand, diluted with water, and the mixture heated; the hydrolyzed mass is concentrated, partly neutralized, filtered and treated as above, or it may be completely neutralized and concentrated to a sirup or to crystallization. (Br. Pat. 147,416—1919; ZELLSTOFFFABRIK WALDHOF and V. HOTTENROTH, Mannheim, Germany, Oct. 6, 1920.)

Hydrogenating Naphthalene.—Naphthalene is hydrogenated by treating while in the fused state and at a temperature above 100 deg. C. with hydrogen in the theoretical quantity and in the presence of a catalyst. Decahydronaphthalene or other less highly hydrogenated products are obtained, and these products are suitable as lamp, motor and lubricating oils, etc. In an example, naphthalene is purified by fusion with fuller's earth or other porous material, after separation mixed with a catalyst consisting of finely divided nickel precipitated on a porous material, and the spongy mass so obtained treated at a temperature of 120 to 150 deg. C. with hydrogen under 3 to 100 atmospheres pressure. (Br. Pat. 147,474—1919; G. SCHROETER, Berlin. See also Br. Pats. 147,476, 147,488 and 147,580—1919. Oct. 6, 1920.)

Alkali Hypochlorites.—A stable preparation for bleaching and disinfecting is prepared from alkali bicarbonates and solid basic magnesium hydrochlorite. In the form of tablets, the mixture remains undecomposed for an indefinite time, and on adding to water, the alkali bicarbonate (potassium bicarbonate is preferably used) attacks the basic magnesium hypochlorite, forming a hypochlorite solution. As this reaction takes place at a continually decreasing velocity, the content of available chlorine, after a short time, tends to remain constant, for the loss due to spontaneous decomposition is partly counterbalanced by the generation of a further quantity of soluble hypochlorite. In the first of two examples dry sodium bicarbonate is mixed with one-third of its weight of basic magnesium hypochlorite, and in the second, this mixture is agitated with water. (Br. Pat. 147,535—1919. G. KERESZTY and E. WOLF, Budapest, Hungary, Oct. 6, 1920.)

Disinfecting Air.—Air is disinfected by passage through a packed tower in counter-current to a solution of ozone in water containing substances serving to increase the solubility of the ozone and to bind it in solu-

tion, prepared according to the process described in German Specification 297,335. The solution, after use, is treated with ozone in a second tower so that it may be used again and the process rendered continuous without the addition of further fresh solution. A portable apparatus may be used and the treated air is stated to be free from ozone and to be suitable for use in the treatment of wounds and of diseases of the breathing-organs. (Br. Pat. 147,566—1919. A. WOLF, Berlin, Oct. 6, 1920.)

Treating Textile Materials.—Textile fibers, such as wool, hair or other animal fibers, cotton, linen or other vegetable fibers, are mixed with a cellulose solution adapted to be converted into artificial silk by treatment with water, acids, ammoniacal copper oxide, zinc chloride or other suitable substances. Artificial fibers may be mixed with a cellulose solution of different composition. A solid mass is thus produced in which fibers are distributed. The fibers may be added while the artificial silk is being formed. The mixture may be allowed to dry in mass and may be reduced by cutting or otherwise to threads, bands, films or non-coherent fibers which may be spun, or the mixture may be molded into cord-shaped masses which may be comminuted to obtain fibers suitable for spinning. The mixture may be forced through tubes and on being introduced into a fixing agent may be drawn out to form threads or films. Bands or films may be formed by mechanical pressure and then treated with fixing agent and dried, the dry films, bands and threads being reduced to spinning fibers by well-known comminuting methods, or the bands may be twisted direct. (Br. Pat. 147,585—1919. E. CLAVIEZ, Adorf, Germany, Oct. 6, 1920.)

Utilizing Waste Rubber.—To recover textile material in a form suitable for spinning or paper making and rubber from waste rubber fabric, such as old cycle or motor tires, the fabric is cut into coarse fragments and treated with solvent under the influence of heat in a closed drum. The fragments are kneaded or agitated mechanically in the solvent until the whole of the rubber has passed into solution. The rubber solution is then run off and distilled to obtain the rubber, and remaining fragments of textile material washed with a fresh lot of solvent, which may be used afterward to treat the next charge. (Br. Pat. 147,628—1919. F. WAITZ, Bremen, Germany, Oct. 6, 1920.)

Preparation of Zinc Sulphide.—Anhydrous zinc sulphide is prepared as described below from the hydrated sulphide obtained by treating zinc hydroxide, heated to 90 to 100 deg. C. by means of steam, with sufficient sodium sulphide. The resulting caustic soda is decanted off and is used to prepare a fresh amount of zinc hydroxide from zinc sulphate. Periodically it is necessary to purify the caustic soda by crystallization and to reject the mother liquor which becomes charged with impurities. The precipitation of the zinc hydroxide is performed hot, to avoid the formation of a gelatinous product of low density, and the sodium sulphate simultaneously produced is used to prepare barium sulphate and sodium sulphide from barium sulphide. The latter is obtained by the reduction of barium sulphate by means of carbon, thus completing the cycle in which zinc sulphide and precipitated barium sulphate are obtained from zinc sulphate, barium sulphate and carbon. The hydrated zinc sulphide after being washed free from alkali is filtered and dried at 100 deg. C. or in a

vacuum. It is then mixed with sulphur and heated to 450 to 500 deg. C. in a muffle furnace, thereby volatilizing any cadmium sulphide, and is allowed to cool with exclusion of air. To prepare a lithopone, the precipitated barium sulphate after washing and drying is mixed with the desired proportion of zinc sulphide in an iron revoluble horizontal cylinder and finally passed through a fine sieve. (Br. Pat. 147,658—1919. J. DE COPPET, France, Oct. 6, 1920.)

Preparation of Hydrofluoric Acid.—Hydrofluoric acid is prepared from sulphuric acid, preferably in the form of monohydrate, and a natural fluoride such as fluorspar by thoroughly mixing equivalent quantities of the two substances with a solid such as finely-ground anhydrous calcium sulphate and heating to 200 to 300 deg. C. By feeding the material into a muffle furnace of the Mannheim sulphate type which is provided with mechanical stirring and discharging devices, the process becomes continuous and the handling of the resulting calcium sulphate charged with hydrofluoric acid is avoided. The hydrofluoric acid may be collected as such, or it may be absorbed by means of alkalis, thereby yielding alkali fluorides. The residual calcium sulphate is used in the preparation of fresh charging material. (Br. Pat. 147,711—1919. VEREIN CHEMISCHER FABRIKEN, Mannheim, Germany, Oct. 6, 1920.)

Oxidizing Oils.—In the oxidation of oils by exposure to oxygen, air or other gas containing oxygen a large reacting surface and easy separation of the viscid or solid product is obtained by mixing the oil with a dispersive medium or diluent that melts at a lower temperature than the product and so is separated by pressure or by centrifuging, or with one from which the product is separated by dissolving out the diluent or the product. Accelerators of the reaction, such as lead or manganese compounds of resinous acid or other siccatives may be added, and linoleum cement may be made directly by addition of gum kauri, colophony or other matters usually added to the oxidized oil. Dispersives or distributors mentioned are neutral or basic salts, such as sodium sulphate or chloride, which are removed from the finished product by washing with water, and tallow, Chinese tallow, paraffine wax, ceresine, stearine, colophony and fully hydrogenated sunflower oil, which are melted to dissolve the oil, the solution being then sprayed or allowed to set and crushed or scraped to obtain a fine powder; or a porous form is obtained by blowing in air during setting if this porosity is not formed naturally. In an example, 750 kilos completely hardened sunflower oil, 22.5 kilos of manganese resinate, and 250 kilos of linseed oil are melted together, allowed to set, powdered, turned over mechanically for about eight hours, melted and pressed. In another, 650 kilos sodium sulphate and 350 kilos train oil are mixed and treated with a current of air in a rotary drum that may be heated up to 110 deg. C. until oxidation is complete. The sulphate is removed by lixiviating with water, or the oxidized oil is extracted by a solvent. In a third example, 800 kilos perfectly hardened sunflower oil, 200 kilos linseed oil and 6 kilos manganese resinate are melted, and air is driven into the mixture as it sets until it is pasty. It is then poured into molds and the porous slabs allowed to stand for twenty-four hours, melted and pressed. (Br. Pat. 147,661—1919. G. SCHICHT AKT. GES., Aussig, and A. EISENSTEIN, Leitmeritz, both in Czechoslovakia, Oct. 6, 1920.)

Current Events

in the Chemical and Metallurgical Industries

Minerals Separation Loses Its Appeal

On Dec. 9 the Circuit Court of Appeals in Philadelphia handed down an opinion in which it most fully sustained Judge Morris' several orders, by which the District Court in Wilmington had dismissed several applications of Minerals Separation of various supplemental bills, in which it sought to have the Miami Copper Co. found in contempt of court and enjoined from continuing to operate its present flotation methods.

Minerals Separation had appealed these orders upon the ground that the District Court had erred in refusing injunctive relief by virtue of its orders of July 23, 1920, and as interpreted and supplemented by an opinion filed July 29, and an order of the court entered Aug. 11, 1920. (See CHEM. & MET. Eng., Aug. 11, 1920, pp. 221 and 254.)

The Circuit Court of Appeals finds that the trial court did exercise its discretion as to proceedings in contempt, and as it held "that the facts set up by the petition are not of the character required to sustain a judgment in contempt," the present opinion infers that the District Court evidently meant that the modification or changes were not plainly mere colorable equivalents of the procedures found to infringe, and that it did not abuse its discretion, adding, "He arrived at the same conclusion at which we would have arrived if we had been in his place."

The opinion of the Circuit Court of Appeals goes thoroughly into the questions as to whether the trial judge rendered his judgment upon a wholly wrong comprehension of the facts or the law, and whether, accordingly, he abused his discretion, "the only respect in which an appellate court will disturb such an order."

This opinion not only most positively asserts that the trial judge has not made any of these errors, but, in ending, adds: "We would have made the same disposition of the case had we been sitting in the District Court."

Conference Committee to Hold Hearings On Patent Office Bill

Plans were perfected on Friday, Dec. 10, for a conference immediately after the holiday recess of Congress on the Nolan Patent Office bill. Contrary to the usual custom, the Conference Committee will conduct hearings, at which further testimony in regard to the bill will be taken.

Section 9 of the Nolan bill adds to the measure the bill originally drafted by Dr. F. G. Cottrell authorizing the Federal Trade Commission to administer patents granted to Government employees. There is considerable opposition to section 9 and it is understood that Dr. Cottrell, Dr. Andrew Stewart and other proponents of the section are unwilling to have it jeopardize the remainder of the Patent Office bill.

Senator Norris, chairman of the Committee on Patents of the Senate, and Representative Nolan, chairman of the Patents Committee of the House are not inclined to eliminate section 9, it is reported.

Meeting California Section, A.C.S.

The annual meeting of the California Section, A.C.S., was held on Dec. 3 at the Engineers' Club in San Francisco. Officers were elected for the ensuing year as follows: Chairman, Dr. W. C. Bray; vice-chairman, B. S. Drake; secretary-treasurer, L. W. Chapman; councillors, Dr. L. H. Duschak, R. A. Gould, Dr. Joel Hildebrand and Dr. R. E. Swain.

Two interesting papers were presented. Prof. S. W. Young of Stanford University discussed the efficiency of the various laboratory types of still-heads used in fractional distillation and described a new type by which it is possible to obtain increased efficiency.

Ludwig Rosenstirn, of the Great Western Electrochemical Co., reviewed the history of the chlorine industry and its relation to the alkali industry, discussing the present status and the effect of the development of the electrolytic process for the production of chlorine and its compounds upon the chemical processes; thus pointing out the importance of a thorough understanding of related industries in the successful conduct of present-day chemical manufacturing.

To Try to Pass Dye Bill

After a conference among those interested in the dyestuffs tariff bill, held in the office of Representative Longworth of Ohio, it was decided to make every effort to secure tariff legislation on dyestuffs at this session of Congress. It was stated at the conference that the failure to enact tariff legislation is having a most untoward effect on the dye industry. Unless this legislation is obtained promptly it was predicted that all but the low-cost producers would be forced to suspend operations. Senator Watson, the acting chairman of the Finance Committee of the Senate, is willing that the dye bill be taken up at the earliest possible moment. Due to the fact that the appropriations bills have right of way and to the fact that there is very determined opposition to the dye bill now on the calendar, it would not be difficult for its enemies to prevent its enactment.

Chlorine May Have Therapeutic Value

The fact that workers in the chlorine cell room at Edgewood Arsenal have been singularly free from any diseases of a pulmonary or bronchial type leads officers of the Chemical Warfare Service to believe that this gas has therapeutic properties. This fact was first noted during the influenza epidemic. Outside of the chlorine room there were numerous cases of influenza, in some rooms amounting to one-third of the number employed. There was not a case in the chlorine room. Since that time the matter has been a subject of some observation, but no technical study has been made of that particular property of the gas. The belief that the gas may have this value is strengthened by the report of the Surgeon General of the Army showing that practically none of the gas casualties were followed by tuberculosis.

Mechanism of Catalytic Processes

A meeting which brought together the New York Sections of the American Chemical Society, American Electrochemical Society, Société de Chimie Industrielle and the American Section of the Society of Chemical Industry was held in Rumford Hall Friday evening, Dec. 10.

A letter from Dr. Parsons conveying to the Section the resolution and recommendation adopted by the Committee on National Policy in regard to the Nolan Patent Office bill was read by the secretary.

Officers of the New York Section, A.C.S., for 1921 were elected as follows: Chairman, John E. Teeple; vice-chairman, Martin H. Ittner; secretary-treasurer, Herbert G. Sidebottom; executive committee, D. W. Jayne, C. H. Herty, C. A. Browne, R. H. McKee.

Dr. Parsons then called attention to the position of the dye bill. It is highly important, he said, that action should be taken during this session of Congress, as the passage of a peace resolution in the spring will jeopardize the dye industry unless protection is assured. Members were asked to send telegrams or to write to their Senators urging immediate action.

MECHANISM OF CATALYTIC PROCESSES

Prof. Hugh S. Taylor of Princeton in a paper on "The Mechanism of Catalytic Processes" reviewed the theories which have been advanced in explanation of the phenomena of homogeneous and heterogeneous catalysis and presented the results of research designed to test experimentally the rival hypotheses.

HOMOGENEOUS CATALYSIS

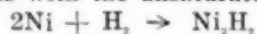
While examples of homogeneous catalysis—such as the hydrolysis of esters and the inversion of cane sugar—have been known for many years, few attempts were made to study the mechanism of the process until comparatively recently. A constantly increasing mass of evidence points toward the formation of intermediate compounds as being the correct explanation. Thus in the case of ester hydrolysis, ester and acid form a binary compound which in turn unites with water to form an unstable ternary complex, capable of breaking down to from either the original substances or the reaction products of hydrolysis. It has been demonstrated that aqueous solutions of an ester and an acid contain definitely measurable quantities of such complexes. A very recent theory involving the absorption of infra-red radiations has not been satisfactorily studied from an experimental point of view.

During the war there was in some European countries a simultaneous demand for fats and glycerine. By the application of homogeneous catalysis it was found possible to replace the glycerine in fats by mannitol and thus obtain both fat and glycerine. The possibilities of such ester exchange are but little realized.

HETEROGENEOUS CATALYSIS

Four theories as to the mechanism of heterogeneous or contact catalysis have received careful consideration. Taking the hydrogenation of unsaturated compounds in the presence of nickel as an example, the theories may be summarized as follows:

Sabatier believes that the nickel forms a hydride which then reacts with the unsaturated compound.



Bancroft believes that there is selective adsorption

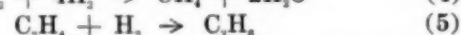
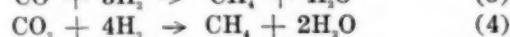
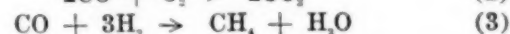
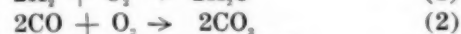
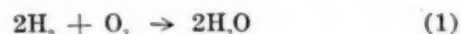
of the reaction products but admits that this hypothesis fails to explain the increased yield of ethylene obtained when steam is mixed with alcohol vapor before being passed over alumina.

Armstrong maintains that the nickel forms a loose complex with the carbon-containing substance, which then reacts with the hydrogen.

The effect of infra-red radiations is held by Lewis to account for the adsorption of hydrogen by nickel, the hydrogen molecule dissociating in the presence of these radiations to form hydrogen atoms.

EXPERIMENTAL INVESTIGATION

In order to get at the facts, Prof. Taylor devised a series of experiments to test out the following reactions:



A glass tube containing nickel precipitated on Nonpareil brick was evacuated and the amounts of nitrogen, hydrogen, carbon monoxide, carbon dioxide and ethylene required to fill the tube at different temperatures were carefully measured. Plotting temperature as abscissa and c.c. of gas as ordinate, some very interesting curves were obtained. Nitrogen which was used as the reference gas gave a line approaching the temperature axis with increasing temperature. CO_2 and H_2 gave lines lying above the N line in the order given, and parallel to it. Since CO forms nickel carbonyl at low temperatures and decomposes into CO_2 and C at high temperatures, only one point could be obtained on this curve (175 deg. C.), but this was above the curve for H_2 . Similarly C_2H_4 gave a point still higher at 175 deg. C. This would indicate that Ni adsorbs C_2H_4 in preference to H_2 .

In similar experiments with copper, the H_2 and CO_2 lines were found to coincide with the N line within the limits of experimental error, while CO and C_2H_4 were markedly adsorbed at low temperatures. At higher temperatures these curves also coincide with the N curve.

Further studies with mixtures of these gases have led to the conclusion that a bimolecular reaction in the gas phase may become a monomolecular reaction on the surface of the catalyst. The catalytic oxidation of SO_2 to SO_3 is an example of this phenomenon. With high concentrations of SO_2 and O_2 the reaction is not termolecular as required by the law of mass action, but toward the end of the reaction series the reaction does become termolecular.

Experiments are now being made using the reaction products of equations 1 to 5 where these have not already been studied.

C.W.S. Asks for \$4,457,376

Congress has been asked by the Secretary of War to appropriate \$4,457,376.20 for the Chemical Warfare Service during the coming fiscal year. Approval was not forthcoming for twice that amount, which General Fries had estimated for the thorough conduct of the work of the next year. This curtailment of the appropriation will limit greatly the plans for quantity production of gas masks. In addition \$35,000 is asked for the maintenance of Chemical Warfare Service schools.

Bureau of Standards Appropriations

Among the appropriations asked by the Bureau of Standards for use in pursuing its work during the next fiscal year are the following:

For metallurgical research, including alloy steels; properties of aluminum alloys; development of metal substitutes; investigation of new metallurgical processes, \$70,000. This is an increase of \$45,000 over the current appropriation.

For apparatus, machinery, appliances, laboratory supplies, furniture for laboratories and cases for apparatus, \$90,000. Increase, \$15,000.

For testing varnish materials, soap materials, inks and chemicals, \$50,000. Increase, \$20,000.

To develop color standards and methods of manufacture and of color measurement, with special reference to their industrial use in standardization and specification of colorants such as dyestuffs, inks and pigments, \$12,000. Increase, \$2,000.

To study methods of measurement and technical processes used in the manufacture of pottery, tile and other clay products \$35,000. Increase, \$10,000.

For the investigation of the problems involved in the production of optical glass, \$40,000. Increase, \$15,000.

To investigate textiles, paper, leather and rubber in order to develop standards of quality and methods of measurement, \$40,000. Increase, \$25,000.

For the standardization and design of sugar-testing apparatus, \$40,000. Increase, \$10,000.

High-temperature measurement investigation, \$15,000. Increase, \$5,000.

To determine experimentally important physical constants of materials, \$25,000. New appropriation.

For purchase, preparation and distribution of standard materials to be used in checking chemical analyses and in the testing of physical measuring apparatus, \$15,000. This is a new appropriation.

For investigation of the problems involved in the electro-deposition of metals, \$15,000. New appropriation.

For the equipment, maintenance and operation of a low-temperature laboratory and the production of liquefied gases, \$15,000. This is a new appropriation.

For an investigation of radio-active substances and the methods of their measurements and testing, \$15,000.

Tariff Hearings Begin Jan. 6

So as to expedite the revision of the tariff, the Ways and Means Committee of the House of Representatives plans to complete its hearings during the present session of Congress, so that the bill may be drafted and its consideration begun promptly after Congress meets in extra session.

Schedule A, which consists of chemicals, oils and paints, will be the first one taken up. Jan. 6, 7 and 8 will be devoted to hearing testimony as to the need of revision of the tariff covering commodities under those heads. Schedule B, which consists of earthenware and glassware, will be considered at the hearings Jan. 10 and 11. The metal schedule is to be considered Jan. 12, 13 and 14. Sugar and manufactures thereof is scheduled for hearing Jan. 18 and 19.

Consulting Chemists' Appointments Approved

The Secretary of War has approved the appointment by General Fries of the fifteen members of the American Chemical Society's advisory committee as consulting chemists of the Chemical Warfare Service.

Personal

Dr. J. F. CARLE, until recently chief chemist at U. S. Nitrate Plant No. 2, Muscle Shoals, Ala., resigned from the Nitrate Division on Nov. 1 to become president of the Southern Testing Laboratories, with headquarters at Birmingham, Ala.

Colonel C. W. EXTON, who recently was transferred to the Chemical Warfare Service, to take charge of the training section, has been designated as assistant chief of the Chemical Warfare Service.

T. G. HAGEMAN, formerly chief engineer of Norsk Hydro-Elektrisk Kvaelfstofaktieselskab (Norwegian Hydro-Electric Nitrogen Co., Ltd.), Christiania, Norway, has started his own business as a consulting engineer for the nitrate industry. His office address will be Ths. Heftyes gate 44, Christiania.

ROBERT B. HITCHCOCK has resigned his position as chief chemist at the coke plant of the Youngstown Sheet & Tube Co., Youngstown, Ohio, to accept a similar position with the Woodward Iron & Steel Co., Woodward, Ala.

FREDERICK P. KEPPEL is on his way to Paris to take up his work as American Administrative Commissioner at the headquarters of the International Chamber of Commerce.

Dr. R. B. MOORE, chief chemist of the Bureau of Mines, announces the selection of the following staff for the cryogenic laboratory which is to be conducted at the Bureau of Mines under his supervision: JOHN W. DAVIS, mechanical engineer; C. W. SEIBEL, chemist, and Dr. LEO FINKLESTEIN, chemist. Mr. Davis has been connected with the faculty of the Leland Stanford University, Mr. Seibel with that of the University of Kansas, and Mr. Finklestein with the University of Chicago.

E. C. MORSE, director of sales, War Department, is terminating his connection with the Government on Dec. 31, and for his work in connection with disposing of the hundreds of millions of dollars of surplus war stock has been awarded the Distinguished Service Medal, which was presented to him by Secretary of War Baker in the latter's office in Washington on Dec. 7.

BENJAMIN SCHNEIDER, of Drydenforth, Lee, Thritton & Wiles, spoke before the Chicago Chemists' Club on Dec. 7 on "The Law of Secret Processes."

At the annual meeting of the American Engineering Standards Committee held in New York on Dec. 4 A. A. STEVENSON, a representative of the American Society for Testing Materials, was re-elected chairman for 1921, and GEORGE C. STONE, a representative of the American Institute of Mining and Metallurgical Engineers, was re-elected vice-chairman.

Obituary

REGIS CHAUVENET, president emeritus of the Colorado School of Mines, Denver, and widely known throughout the country as a chemist and metallurgist, died on Dec. 5. He was seventy-eight years old.

GUSTAVE DROBEGG, a consulting chemist and a director of several dye manufacturing companies, died in the Swedish Hospital, Brooklyn, N. Y., on Dec. 6 in his sixtieth year. Mr. Drobegg had been connected with the firm of Charles Pfizer & Co. in Manhattan and Brooklyn for twenty-five years and was one of the most prominent men in the work of creating the American dye industry during the war. He was a native of Coblenz, Germany, and studied chemistry at the University of Munich. He was a member of the

Chemists' Club, Society of Chemical Industry and other societies.

EDWARD HERMS of North Tonawanda, N. Y., passed away on Nov. 4, after a prolonged illness with heart trouble. For a number of years he was chemist for the Commonwealth Steel Co., St. Louis, Mo., then superintendent of the Strong Steel Foundry, Buffalo, N. Y., superintendent of the open-hearth department of the Pittsburgh Steel Foundry and at the time of his death was employed as chemist of the Buffalo Bolt Co., North Tonawanda, N. Y.

ERNEST MCAULAY, manager of the Mines & Smelter Supply Co., El Paso, Tex., died on Nov. 20.

Book Reviews

THE MODERN ELECTROPLATER. By Kenneth M. Coggeshall. New York: Norman W. Henley Publishing Co. Price \$3.

The actual work that is being done by the electroplater of today is too little understood and a story of the "Modern Plater" would make interesting reading. The author fails to keep to his subject, and shows that he is not in touch with and even discredits the knowledge and ambitions of the modern plater when he states: "It is not necessary that an electroplater be a careful student of either electricity or chemistry. A technical discussion of laws relating to electrochemistry would undoubtedly have but little interest for even an expert plater." He is consistent, however, as he measures up to his own foot-rule when he endeavors to discuss the technical or practical part of electroplating, standing on tiptoes to keep his head above water.

The modern plater is growing beyond "rule-of-thumb" methods, regulation of amount of metal deposited by the voltage and trying to determine the metal and chemical content of a plating solution with a hydrometer—all of which are recommended in this book.

The author has been a careful student of trade catalogues, and gives in brief the story of what is needed in a plating and polishing room which may be of interest to a novice. The practical part offers nothing but what is generally known and with some of which the author is just about on speaking terms.

Silver can be and is deposited with a current density of 5 amp. per sq.ft., which is twice the rate given, and when a silver "strike" is used, "The work is (not) dipped for a moment in a hot potash bath and then transferred, without rinsing, to the 'strike' solution" (p. 185). Even a "careful student" would soon get into trouble if that method was followed.

For making a nickel solution a definite formula is recommended: Water, 1 gal.; nickel ammonium sulphate, 14 oz.; boric acid, 2 oz., and then it is recommended that "The nickel ammonium sulphate is dissolved in hot water, then a quantity of the latter is added to the solution until a hydrometer reading shows a density of about 7 deg. Bé." The author probably does not mean boric acid by "the latter." Fourteen ounces of nickel ammonium sulphate in a gallon of water will give the density of 7 deg. Bé. That is above the point of saturation at ordinary plating room temperature during the winter months, and crystallization will result.

That aluminum is violently attacked by a caustic alkali is well known, and the author is incorrect in stating, "Aluminum wire baskets or trays, for example, are affected to some extent by both potash and muriatic acid . . . and are nevertheless quite popular . . ." Aluminum baskets can be used in "bright dips" but not in "potash" solutions.

Common high brass, such as is commercially used, generally consist of about 64 per cent copper and 36 per cent zinc and not 60-40 (p. 163). Gold when alloyed to make any carat is not alloyed with copper alone (p. 172).

In "A Manual of Electro-Metallurgy," James Napier, 1853, it is stated that the electroplating of iron with zinc from a zinc sulphate and a zinc cyanide solution was done

at that time, yet the author states, "Until recently a process known as hot galvanizing was employed in all instances where this film of zinc was required."

Nothing of any value has been added to modern electroplating practice in bringing out this book, and it will soon take its place among those of which there are now already too many.

GEORGE B. HOGABOOM.

Current Market Reports

The Chemical and Allied Industrial Markets

New York, Dec. 13, 1920.

The chemical market showed flashes of activity during the past week and it was apparent that the prolonged period of readjustment has brought the industry into a healthier position. Inquiries from northern Europe were noted in more volume of leading chemicals, although domestic consumers still showed the same conservatism in their operations. Several interests close to the pulse of trade asserted that the new year will occasion a renewal of buying activity. They are consequently looking forward to its advent. When business assumes normal dimensions there will be a lack of inflation and prices will adhere more to the law of supply and demand than at any time in recent years.

Small sales of zinc sulphate are reported to tanneries, textile mills and paint factories, but business has shown no real punch of late. Producers hold carload lots at 3½c. per lb. and smaller quantities up to 4c. per lb. Factors in zinc chloride are booking business in the granular grade at prices ranging from 12c. to 14c. per lb., the inside figure being for carlots. Fused material is bringing 9@11c. per lb. according to quantity. Sulphite of soda producers report sales of crystals at 4c. per lb. in large quantities and up to 4½c. per lb. in smaller lots. Moderate inquiries were reported.

Large sellers of carbonate of potash quoted the market at 12½c. per lb. spot for the 80-85 per cent grade in large lots and 13c. per lb. in smaller quantities, with only quiet trading. Supplies appear fully adequate to take care of prevailing inquiry.

Some sales of arsenic were reported to manufacturers of insecticides, but the principal movement at present is against old contract orders. Small lots of white powdered are on the market at 12@13c. per lb. The red variety is quoted by producers at 15c. per lb. Dealers reported sales of bleaching powder for domestic consumption at 3c. per lb. f.o.b. New York. Resale material at the works was quoted at the same figure. The movement has remained quiet since the recent sharp decline of this article. A feature of the market was the brisk trading noted in oxalic acid. Surplus spot stocks on the market have been entirely cleaned up and leading factors were quoting prices ranging from 19c. to 21c. per lb. All indications point to a strong market with fluctuating prices.

Supplies of peroxide of soda continued scarce and the market is quoted firm at 35c. per lb. Producers are not very eager to quote at present and the only quotations heard are from dealers. Spot bichromate of soda, standard brands, was generally quoted at 9½@10c. per lb. December shipments of resale stock were quoted at 9½c. per lb. f.o.b. works. The tone of the market remained quite steady.

COAL-TAR PRODUCTS

The coal-tar products market is slowly but surely approaching the period where a strong demand must take the place of the present stagnancy. While there is not very much indication on the surface to warrant such a condition, there is, nevertheless, an undercurrent of feeling in many quarters that point to a much better business shortly after the first of the year. Color manufacturers are steady in their views on an improvement in the demand over next year and while prices are sagging in their industry through the natural law of lack of demand at this time, opinions seem to be of a more optimistic nature. The situation as regards

a steady supply of crude products seems good as to raw material, coal and working conditions at the various plants.

Consumers are showing very little interest in *xylene* at present and only routine trading is heard with figures quotably unchanged at 45@50c. per lb. There are not many sources of supply on *monochlorbenzene*, although the market is said to be fairly easy on supplies at a range of prices from 17c. to 18c. per lb. Producers stated that a limited quantity is moving into various consuming channels.

A slightly better demand for *aniline oil* was reported in some directions, although sales were confined mostly to small quantities. Supplies are plentiful in second hands with prices ranging from 24c. to 26c. per lb. Manufacturers are still quoting 28@30c. per lb. and are waiting for a real demand to set in. The *aniline salts* market is quiet in all quarters. Producers are firm in their views and quote 32@34c. per lb., depending on quantity. Very little *benzidine base* is moving into domestic channels, where there is some inquiry reported from foreign consumers. Available supplies of the base and sulphate material are quoted at \$1.05@\$1.15 per lb. Factors in the *dimethylaniline* market find the call reduced to a minimum. A fair amount of supplies is available, but no heavy offerings are noted. Prices range from 70c. to 85c. per lb., depending on seller.

GROWTH OF THE COAL-TAR INDUSTRY

A recent report of the United States Tariff Commission stated that the production of coke and the byproducts obtained from coal distillation in 1919 showed a slight decrease in the amount of tar distilled and a large decrease in the output of pure benzene and especially of pure toluene. A great significance is attached to the future of the coal-tar industry in the fact that the productive capacity of byproduct coke ovens in the United States increased over 17.2 per cent during 1919. There is no doubt that, with the exception of anthracene, sufficient supplies of the basic materials of coal-tar origin will be available from American sources for the growth of the industry.

Considerable progress has been made during the past year in the case of anthracene, but the problem of securing adequate supplies is still unsolved. In 1919 the output was three times as large as in 1918, or about 800,000 lb., and a much larger quantity was refined than in 1918. Although this showed a greater and more encouraging progress, a larger increase in output must be secured before there will be enough American anthracene available to supply the dye industry. It is believed that the 1919 production of crude anthracene contained less than one-quarter the amount which would be required to supply the American demand. The real difficulty is not primarily an actual lack of anthracene in the tar or purely technical difficulties, but rather the fact that its removal leaves the pitch so hard that it does not find a ready market under American conditions.

PRODUCTION OF INTERMEDIATES

As was expected, there was a sharp decrease in the output of several intermediates needed primarily for explosives. The most noticeable case was phenol, which showed an enormous production—100,000,000 lb. in 1918—but fell to less than 1,500,000 lb. in 1919, nearly all of this being obtained from coal tar. Another example was the case of monochlorbenzene, which had an output of 20,000,000 lb. in 1918 and 4,000,000 lb. in 1919. There was also a considerable decrease in several intermediates required for making dyes used for army uniforms. For example, there was a marked decrease in the output of metatoluylenediamine, which was used for making a khaki dye for cotton uniforms, and a tremendous drop in metanitriline, which was used for making a khaki dye for wool uniforms.

A comparison of the intermediates produced in 1918 and 1919 shows a considerable increase in the number of intermediates. In 1919 there was almost twice as many different intermediates produced as in 1918. Intermediates which had a strong demand and whose manufacture had been well established by 1918 showed comparatively little change in 1919. Nitrobenzene gained about 10 per cent, the 1919 output amounting to about 42,000,000 lb. Aniline production

was about 25,000,000 lb., a gain of 1 per cent. The output of U.S.P. benzoic acid increased from about 175,000 lb. in 1918 to over 600,000 lb. in 1919, with a drop in price from \$3 per lb. to 75c. per lb. Orthotoluidine increased from 650,000 lb. in 1918 to a little over 1,000,000 lb. in 1919. The general increase in the output of intermediates derived from toluene is due to relaxation of the restriction in the use of toluene during war times. Progress among anthracene derivatives is of special interest. In 1919 there were ten intermediates derived from anthracene, against only five in 1918. The output of anthraquinone, which is the most important, because it serves as raw material for the manufacture of nearly all other intermediates derived from anthracene, was about ten times as great in 1919 as in 1918.

VEGETABLE OILS

The market on vegetable oils remained quiet and has shown no tendency of firmness for the past few weeks. Trading was practically of a hand-to-mouth nature. Resale offerings of *coconut oil* on the Coast brought out sharply lower prices for manila oil. Offerings were heard at 10c. per lb. sellers' tanks, December shipment, and 10½c. per lb. January shipment. Ceylon grade oil was offered in barrels at 13½c. per lb. New York. The market for *corn oil*, crude, held around 9½c. per lb. with no business being reported. Oriental *peanut oil* was easier and sellers called for bids around 8½c. per lb., sellers' tanks, December shipment from the Pacific Coast. Buyers' ideas were about ¼c. under this basis.

Buyers and sellers were apart from their views on *soya bean oil*, with the result that no business was placed. December shipment from the Coast closed at 6c. per lb. January-March shipment closed at 6½c. per lb. sellers' tanks, f.o.b. Pacific Coast. The spot market was nominal at 9½c. per lb., no sales being reported. The market for *cottonseed oil* was a featureless affair, demand being only of a moderate nature. Prime summer yellow was quoted at 9½c. per lb., with only small inquiries noted for European ports. *Crude oil* held at 6½c. per lb. f.o.b. mill.

The Chicago Market

Chicago, Dec. 8, 1920.

It seems there is no degree of quietness to which the chemical market can attain which is not immediately outdone by more pronounced quiet. The fact is that the past ten days have been more excessively dull than any foregoing period in the year. On all hands production has been curtailed and yet demand does not absorb supply. Low prices seem to have no attraction and normally heavy buyers content themselves with small routine purchases, ignoring opportunities to stock up at prices which, a few weeks ago, would have looked like real bargains.

The attitude of consumers is that anything is possible in regard to prices in the immediate future and they are going to stay out until the market is stabilized. Bona fide buyers are able to get goods at practically their own terms and nothing like heavy buying is seen in any line.

HEAVY CHEMICALS

A lowering in price on various items and a lack of interest on the part of all buyers are outstanding features of the past two weeks. Sales of *bleaching powder* have been reported as low as 2½c. per lb. and offers at around 3c. for spot goods are plentiful. Some future business is reported at 3½c. *Caustic soda* is likewise hard to sell, 4c. being the prevailing price on the small lots going. Stocks are light but demand is absent. Bottom is being approached on *soda ash*, offers at \$1.85 failing to produce business. Buyers could probably secure concessions from this figure. *Sal soda*, held at \$2 per 100 lb., is quiet.

Alcohol, with prices firm, is experiencing a lack of demand. Ethyl grade, 190 proof, is quoted at \$5.15 per gal.; methyl grade, 97 per cent, at \$1.95, and denatured, 96 per cent, at 85c. Holders of resale stock show a disposition to shade these prices. Depression in consuming trades is weakening this market. Output of *glycerine* is remarkably light, but at that is more than equaling demand. The c.p.

grade, less drums, has changed hands in small quantities at 18c., and dynamite grade is offered at 17c.

Low prices prevailing in the copper market have carried *blue vitriol* down to \$6.75@6.85 per 100 lb. for 99 per cent grade, which prices are firmly held by a good demand. *Salt cake*, with consuming demand steady, holds firm at \$31 per ton. *Ammonia* is weak and uncertain, small lots only being taken at from 10@11c. per lb. for 26 degree. Producers' quotations are unchanged.

The acid market, in common with other chemical lines, shows lack of interest. *Sulphuric* is off in price as well as demand, 66 degree being offered at \$22 per ton. Some transactions are reported at \$1@1.50 below this figure. *Nitric*, in a dull market, is offered by producers at \$7.75@8 per 100 lb. for 42 degree. The fact that Government supplies of *carbolic acid* are held at 12c. per lb. has had no effect on the market, sales from stock being made at from 7@7½c. per lb. Plentiful supply is available. Business in *acetic acid* is dull, the glacial being offered at 10c. and the 28 per cent at \$3 per 100 lb. in barrels.

VEGETABLE OILS

While the trading in *flaxseed* has been stimulated somewhat by bullish reports from Argentina, no effect has been felt in the *linseed oil* market. Low prices are not operating to stimulate demand, business being practically confined to small lots. It would seem as though the bottom had been reached, as bulk is offered in tanks as low as 70c. per gal., with but few takers. Oil in barrels, carload lots, is 77c., and dealers are selling 1- to 5-bbl. quantities of stock at 97c.

Cottonseed oil, offered at 6c. per lb. in sellers' tanks at point of production, is a drug on the market. Consuming demand is notable for its weakness and prime summer yellow, offered in tanks, delivered, at 7c. per lb., has few takers. *Coconut oil*, Manila variety, is offered f.o.b. Coast in sellers' tanks at 10½@11c. per lb. and the refined edible kind is quoted here at 16½c. in barrels. Curtailed production of *corn oil* has been equaled by lower demand, and recent transactions have passed at 6½c. per lb. in cars f.o.b. Chicago. The edible refined now brings 12½c. per lb. in barrels.

NAVAL STORES

Gradually lowered prices are still the feature in naval stores, notwithstanding the fact that the producing season is closing with stocks below normal. Demand is light, but dealers do not attribute recent price drops to this so much as to the habit naval stores prices have of taking a December slump. Curtailed activities on the part of consuming buyers have permitted a little drop in prices of *pine oil*, the pure steam distilled now being quoted at \$1.60 and the destructively distilled at \$1.50. *Rosin oil*, first rectified, is offered at 66c. and commercial *pine tar oil* at 47c. *Turpentine*, weak under poor demand, is quoted at 90c. per gal.

The St. Louis Market

St. Louis, Dec. 10, 1920.

The inactivity of heavy chemical demand has become even more pronounced here during the past two weeks and the amount of spot business has become negligible. New contract business has slowed up considerably also, but shipments on contracts still average close to normal, according to producers, and a good many contracts are being renewed. Producers report that consumers are buying only for their immediate needs and that their needs are being decreased materially by the depression in other lines. Little change in this situation is looked for before the first of the year and no impressive upturn is expected then. In spite of the quiet market producers are holding both spot and contract prices at the levels reported previously and feel that they will not be forced to alter them materially in the near future.

There is still some call for the 66 deg. *sulphuric acid*, this coming mainly from the oil fields where production and refining show no signs of slackening. Prices hold firm at \$22 per ton and 1½c. per lb. carload lots. Demand is slow for the 98 deg. *sulphuric acid*. A quotation of \$25 per ton f.o.b. works is being maintained. Inactivity marks the 60 deg. *sulphuric acid* market and producers are asking \$16.50

per ton and 1½c. per lb. in carboys. *Oleum* is slow at \$28.50 per ton.

Producers are still keeping their supplies of *muriatic acid* low, though demand has been very quiet, and prices are firm at 1½@2c. per lb. and \$25 per ton in bulk.

Sodium bisulphate (niter cake) is slightly more active than two weeks ago, with prices being maintained at \$7@8 per ton.

Both inquiries and orders for *nitric acid* continued to fall off, but producers report deliveries on contracts about normal. This is taken to mean that consumers' needs have not decreased materially, but that where they must re-enter the market for supplies they are buying from hand to mouth. Quotations are \$7 per 100 lb. for the 36 deg. test and \$10 per 100 lb. for the 42 deg. test. *Standard mixed acid* is quoted at 1½c. per lb. of sulphuric content and 11½c. per lb. for unit of nitric acid.

The Iron and Steel Market

Pittsburgh, Dec. 10, 1920.

In the past week the independent market on sheets has declined to the Steel Corporation or Industrial Board level: Blue annealed sheets, 10 gage, 3.55c.; black sheets, 28 gage, 4.35c.; galvanized sheets, 28 gage, 5.70c. Previously there had been similar reversions in tin plate, bars, shapes, plates and wire products. Of the important steel mill products pipe alone remains as presenting a higher market on the part of the independents than the Steel Corporation level. The exception is not especially important in itself, for the reason that the large delivery premiums formerly obtained by independents have practically disappeared, leaving the independent market on the regular independent list, which is only 3½ points or about \$7 a ton above the Steel Corporation schedule. The exception is of importance, however, in this respect, that alone of all steel products pipe is in good demand, with heavy requirements against contracts and a moderate amount of new buying. The pipe mills are comparatively busy, in general, while the leading interest has difficulty in meeting customers' requirements, although for two or three weeks past it has been shipping up to its loading capacity, or at about 30 per cent above production, which is substantially at capacity. During the period of car scarcity a stock was accumulated equal to about a month's production.

MARKET STAGNANT

The stagnation in the finished steel market continues. The price reductions by independents have had no appreciable effect, although it should be understood that there was no definite hope that much business would be developed, at least at the outset, by the reductions. The independent mills simply abandoned a position that had become untenable and that they knew would have to be abandoned some time.

The Steel Corporation continues to operate to the physical limit in nearly all departments. The supply of coal and coke has improved and a few additional blast furnaces have been blown in, so that the corporation is probably operating at a slightly heavier rate than a couple of months ago. The independents, on the other hand, have steadily dwindling operations. Not a few are closed entirely, though probably not permanently, as some orders may accumulate for a run of a week or two. Others are operating at 60 to 75 per cent, and the general average is probably under 50 per cent.

The independents having reduced their prices to the Steel Corporation level, the next point is whether they will shade the Steel Corporation prices. There seems to be practically no doubt that some of them will. The present stagnant market is no test, since there is no incentive to make special prices. The real test will probably come in January, when in the course of events there should be somewhat more buying. Buyers cannot indefinitely stay so completely out of the market as they are at present.

Inasmuch as common expectation is that there will be no full demand for steel for many months, sufficient to engage all the capacity, the question is discussed whether, or when, the Steel Corporation will itself reduce prices. At present it has well-filled order books, apparently sufficient to

enable it to maintain approximately the present rate of operation until some time in the second quarter of the new year. Judge Gary's statement three weeks ago today, to the effect that the corporation would not alter its prices, had the specific qualification "unless and until it becomes necessary and proper to make changes to meet altered conditions." The immediate bearing was that the corporation would not advance its prices, as for a long time the independents had hoped, but it is plain that if demand for steel remains light for a period of months there is a prospect of business in general undergoing such a general readjustment that the corporation's costs will be reduced, and that would furnish a basis for reduced prices. As long as the corporation was operating at a much higher rate than the independents it would hardly reduce prices because of price cutting by independents. With a fair operation the Steel Corporation prices should prove quite profitable, unless to independents who have saddled themselves with extra costs during the period when prices were so high that costs were a minor consideration. It must be remembered that the Steel Corporation's total profits have been much larger than the net earnings reported, by reason of various heavy deductions and allowances being made for contingencies.

SEMI-FINISHED STEEL

There is no market at all in semi-finished steel, and prices are altogether nominal. It is assumed that if any important business were offered some at least of the independents would meet the Steel Corporation prices of \$47 on sheet bars and \$57 on rods, these prices being \$5 above the Industrial Board schedule by reason of advances the corporation made in August and September. The corporation does not seem to have advanced its billet price above the \$38.50 figure of the Industrial Board schedule, and there is no doubt that no independent would name that price. In some quarters it is doubted whether the corporation will continue its present prices on sheet bars and rods, there being a possibility of its going back to the old prices.

NOVEMBER PRODUCTION

The thirty companies making monthly reports for their ingot production to the American Iron and Steel Institute showed an output in November of 2,638,670 tons, against almost precisely 3,000,000 tons in each of the three preceding months. All four months had twenty-six working days each. The report shows a decrease of 13 per cent in output in November. The reporting companies made about 84 per cent of the total output in 1918 and about 85 per cent in 1919. Ordinarily it may be assumed that the producers not reporting had approximately the same variations in output from month to month as the companies reporting, but in the case of November such an assumption is not correct, since the report doubtless includes all the Steel Corporation's output, the companies not reporting being among the independents. The corporation's output did not decrease materially from October to November, and probably increased somewhat. A computation taking this into account suggests that if the corporation's output was unchanged from October to November the output of the independents decreased by about 28 per cent, whereby the entire output decreased about 15 per cent. As independent production declined continuously the rate at present is much below the November average.

PIG IRON

Little change has occurred in pig iron prices in the past week. Prices on an average are approximately 20 per cent under the top level reached late last August and about 50 per cent above the Industrial Board schedule, which represented the market from the time of the Industrial Board adjustment, March 21, 1919, until October following. Declines thus far have been almost voluntarily on the part of furnaces, not being occasioned by competition for business, since scarcely any business has been offered. The remainder of the decline is likely to be left quite largely for more competitive times. Quotations for the valley market are: Foundry, \$37; bessemer, \$35; basic, \$33.

General Chemicals

CURRENT WHOLESALE PRICES IN NEW YORK MARKET

	Carlots	Less Carlots
Acetic anhydride.....lb.		\$0.65 - \$0.75
Acetone.....lb.	\$0.13 - \$0.13	.13 - .14
Acid, acetic, 28 per cent.....100 lbs.	3.00 - 3.25	3.50 - 3.75
Acetic, 56 per cent.....100 lbs.	7.25 - 7.50	7.75 - 8.00
Acetic, glacial, 99½ per cent, carboys.....100 lbs.	10.50 - 11.00	11.25 - 11.50
Boric, crystals.....lb.	.14 - .15	.15 - .16
Boric, powder.....lb.	.15 - .16	.17 - .18
Citric.....lb.		.50 - .52
Hydrochloric (nominal).....100 lb.	1.85 - 2.25	2.75 - 3.00
Hydrofluoric, 52 per cent (nominal).....lb.	.15 - .16	.16 - .18
Lactic, 44 per cent tech.....lb.	.10 - .11	.11 - .12
Lactic, 22 per cent tech.....lb.	.04 - .05	.06 - .07
Molybdic, C. P.....lb.	4.00 - 4.50	4.50 - 5.00
Muriatic, 20 deg. (see hydrochloric).....lb.		
Nitric, 40 deg.....lb.	.07 - .07	.08 - .08
Nitric, 42 deg.....lb.	.07 - .08	.08 - .09
Oxalic, crystals.....lb.	.18 - .19	.19 - .20
Phosphoric, Ortho, 50 per cent solution.....lb.	.19 - .19	.19 - .21
Picric.....lb.	.28 - .35	.40 - .50
Pyrogallol, resublimed.....lb.	2.30 - 2.55	2.60 - 2.65
Sulphuric, 60 deg., tank cars.....ton		14.00 - 15.00
Sulphuric, 60 deg., drums.....ton		
Sulphuric, 66 deg., tank cars.....ton	18.00 - 19.00	
Sulphuric, 66 deg., drums.....ton	21.00 - 22.00	22.50 - 23.00
Sulphuric, 66 deg., carboys.....ton		
Sulphuric, fuming, 20 per cent (oleum) tank cars.....ton	23.00 - 24.00	
Sulphuric, fuming, 20 per cent (oleum) drums.....ton	25.00 - 26.00	26.50 - 27.00
Sulphuric, fuming, 20 per cent (oleum) carboys.....ton	32.00 - 35.00	40.00 -
Tannic, U. S. P.....lb.		1.30 - 1.35
Tannic (tech.).....lb.	.50 - .55	.56 - .60
Tartaric, crystals.....lb.		.43 - .45
Tungstic, per lb. of WO.....lb.		1.20 - 1.40
Alcohol, Ethyl (nominal).....gal.		5.50 - 6.00
Alcohol, Methyl (see methanol).....gal.		
Alcohol, denatured, 188 proof (nominal).....gal.		.84 - .86
Alcohol, denatured, 190 proof (nominal).....gal.		.88 - .90
Alum, ammonia lump.....lb.	.04 - .04	.05 - .05
Alum, potash lump.....lb.	.05 - .06	.06 - .07
Alum, chrome lump.....lb.	.13 - .13	.14 - .14
Aluminum sulphate, commercial.....lb.	.02 - .03	.03 - .03
Aluminum sulphate, iron free.....lb.	.03 - .04	.04 - .04
Aqua ammonia, 26 deg., drums (750 lb.).....lb.	.07 - .08	.08 - .09
Ammonia, anhydrous, cylinders (100-150 lb.).....lb.	.33 - .35	.36 - .38
Ammonium carbonate, powder.....lb.	.14 - .14	.14 - .15
Ammonium chloride, granular (white sal-ammoniac).....lb.	.12 - .12	.12 - .13
Ammonium chloride, granular (gray sal-ammoniac).....lb.	.11 - .12	.12 - .13
Ammonium nitrate.....lb.	.11 - .10	.11 - .14
Ammonium sulphate.....lb.	.04 - .04	.04 - .04
Amylacetate.....gal.		4.50 - 5.00
Amylacetate, tech.....gal.		4.00 - 4.20
Arsenic, oxide, lumps (white arsenic).....lb.	.12 - .12	.12 - .13
Arsenic, sulphide, powdered (red arsenic).....lb.	.15 - .15	.15 - .16
Barium chloride.....ton	85.00 - 90.00	95.00 - 100.00
Barium dioxide (peroxide).....lb.	.24 - .25	.26 - .27
Barium nitrate.....lb.	.12 - .12	.13 - .13
Barium sulphate (precip.) (blanc fixe).....lb.	.04 - .05	.05 - .06
Bleaching powder (see calcium hypochlorite).....lb.		
Blue vitriol (see copper sulphate).....lb.		
Borax (see sodium borate).....lb.		
Bromine (see sulphur, roll).....lb.	.50 - .52	.54 - .56
Calcium acetate.....100 lbs.	2.00 - 2.25	
Calcium carbide.....lb.	.04 - .04	.04 - .05
Calcium chloride, fused, lump.....ton	30.00 - 32.00	33.00 - 35.00
Calcium chloride, granulated.....lb.	.02 - .02	.03 - .03
Calcium hypochlorite (bleaching powder).....lb.	.03 - .03	.03 - .04
Calcium peroxide.....lb.		1.50 - 1.70
Calcium phosphate, monobasic.....lb.		.75 - .80
Calcium sulphate, pure.....lb.		.25 - .30
Camphor.....lb.		.95 - 1.00
Carbon bisulphide.....lb.	.08 - .08	.09 - .09
Carbon tetrachloride, drums.....lb.	.13 - .13	.14 - .14
Carbonyl chloride (phosgene).....lb.		.60 - .75
Caustic potash (see potassium hydroxide).....lb.		
Caustic soda (see sodium hydroxide).....lb.		
Chlorine, gas, liquid-cylinders (100 lb.).....lb.	.09 - .09	.10 - .10
Chloroform.....lb.		.43 - .50
Cobalt oxide.....lb.		3.90 - 4.00
Copperas (see iron sulphate).....lb.		
Copper carbonate, green precipitate.....lb.	.22 - .22	.22 - .23
Copper cyanide.....lb.		.65 - .70
Copper sulphate, crystals.....lb.	.06 - .06	.07 - .07
Cream of tartar (see potassium bitartrate).....lb.		
Epsom salt (see magnesium sulphate).....lb.		
Ethyl Acetate Com. 85%.....gal.		1.05 - 1.10
Ethyl Acetate pure (acetic ether 98% to 100%).....gal.		
Formaldehyde, 40 per cent (nominal).....lb.	.19 - .19	.19 - .20
Fusel oil, ref.....gal.		3.60 - 3.75
Fusel oil, crude (nominal).....gal.		2.50 - 2.75
Glauber's salt (see sodium sulphate).....lb.		
Glycerine, C. P. drums extra.....lb.		.21 - .22
Iodine, resublimed.....lb.		3.85 - 4.00
Iron oxide, red.....lb.		.15 - .25
Iron sulphate (copperas).....100 lbs.	1.50 - 1.75	2.00 - 2.25
Lead acetate, normal.....lb.		.13 - .16
Lead arsenate (paste).....lb.	.13 - .14	.14 - .15
Lead nitrate, crystals.....lb.		.90 - 1.00
Litharge.....lb.	.12 - .12	.13 - .13
Lithium carbonate.....lb.		1.50 -
Magnesium carbonate, technical.....lb.	.10 - .11	.11 - .12
Magnesium sulphate, U. S. P.....100 lb.	3.00 - 3.25	
Magnesium sulphate, commercial.....100 lb.		2.50 - 2.75
Methanol, 95%.....gal.		1.90 - 2.00
Methanol, pure.....gal.		2.30 - 2.35
Nickel salt, double.....lb.		.12 - .12
Nickel salt, single.....lb.		.13 - .13
Phosgene (see carbonyl chloride).....lb.		
Phosphorus, red.....lb.	.50 - .52	.53 - .55
Phosphorus, yellow.....lb.		.35 - .37
Potassium bichromate.....lb.	.20 - .21	.21 - .22

	Carlota	Less Carlota
Potassium bitartrate (cream of tartar).....lb.	50.43	50.47
Potassium bromide, granular.....lb.	45	50
Potassium carbonate, U. S. P.....lb.	50	55
Potassium carbonate, crude.....lb.	13	13
Potassium chlorate, crystals.....lb.	13	14
Potassium hydroxide (caustic potash).....lb.	16	16
Potassium iodide.....lb.	3.00	3.20
Potassium nitrate.....lb.	14	16
Potassium permanganate.....lb.	50	55
Potassium prussiate, red.....lb.	55	57
Potassium prussiate, yellow.....lb.	34	35
Potassium sulphate (powdered).....ton	240.00	255.00
Rochelle salts (see sodium potas. tartrate).....		
Sal ammoniac (see ammonium chloride).....		
Sal soda (see sodium carbonate).....		
Salt cake.....ton	45.00	50.00
Silver cyanide (nominal).....oz.	1.25	
Silver nitrate (nominal).....oz.	46	48
Soda ash, light.....100 lb.	1.90	2.00
Soda ash, dense.....100 lb.	2.50	2.75
Sodium acetate.....lb.	08	08
Sodium bicarbonate.....100 lb.	2.75	2.85
Sodium bichromate.....lb.	09	10
Sodium bisulphate (nitre cake).....ton	7.00	7.50
Sodium bisulphate powdered, U. S. P.....lb.	06	07
Sodium borate (borax).....lb.	08	08
Sodium carbonate (sal soda).....100 lb.	1.85	2.00
Sodium chlorate.....lb.	10	10
Sodium cyanide, 96-98 per cent.....lb.	24	25
Sodium fluoride.....lb.	17	17
Sodium hydroxide (caustic soda).....100 lb.	3.75	4.00
Sodium hypsulphite.....lb.		
Sodium molybdate.....lb.	2.50	3.25
Sodium nitrate.....100 lb.	2.85	3.00
Sodium nitrite.....lb.	07	07
Sodium peroxide, powdered.....lb.	35	40
Sodium phosphate, dibasic.....lb.	03	04
Sodium potassium tartrate (Rochelle salts).....lb.		
Sodium prussiate, yellow.....lb.	18	18
Sodium silicate, solution (40 deg.).....lb.	01	01
Sodium silicate, solution (60 deg.).....lb.	03	03
Sodium sulphate, crystals (Glauber's salt) 100 lbs.	1.75	2.00
Sodium sulphide, crystals, 60-62 percent (conc) lb.	07	07
Sodium sulphite, crystals.....lb.	04	04
Strontium nitrate, powdered.....lb.	15	15
Sulphur chloride red.....lb.	08	09
Sulphur, crude.....ton	16.00	20.00
Sulphur dioxide, liquid, cylinders.....lb.	09	
Sulphur (sublimed), flour.....100 lb.	3.70	4.35
Sulphur, roll (brimstone).....100 lb.	3.40	3.90
Tin bichloride, 50 per cent.....lb.	11	12
Tin oxide.....lb.		
Zinc carbonate, precipitate.....lb.	16	18
Zinc chloride, gran.....lb.	12	13
Zinc cyanide.....lb.	45	49
Zinc dust.....lb.	12	13
Zinc oxide, XX.....lb.	09	09
Zinc sulphate.....lb.	03	04

Coal-Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude.....lb.	\$1.10	\$1.15
Alpha naphthol, refined.....lb.	1.45	1.50
Alpha-naphthylamine.....lb.	47	50
Aniline oil, drums extra.....lb.	30	30
Aniline salts.....lb.	30	32
Anthracene, 80% in drums (100 lb.).....lb.	90	1.00
Benzaldehyde (f.f.c.).....lb.	2.00	2.10
Benzidine, base.....lb.	1.10	1.15
Benzidine sulphate.....lb.	1.05	1.10
Benzoic acid, U. S. P.....lb.	75	80
Benzoate of soda, U. S. P.....lb.	75	85
Benzene, pure, water-white, in drums (100 gal.).....gal.	35	40
Benzene, 90% in drums (100 gal.).....gal.	35	33
Benzyl chloride, 95-97% refined.....lb.	35	40
Benzyl chloride, tech.....lb.	40	45
Beta-naphthol benzoate (nominal).....lb.	3.50	4.00
Beta-naphthol, sublimed (nominal).....lb.	75	80
Beta-naphthol, tech (nominal).....lb.	40	45
Beta-naphthylamine, sublimed.....lb.	2.25	2.40
Cresol, U. S. P., in drums (100 lb.).....lb.	18	19
Ortho-cresol, in drums (100 lb.).....lb.	23	25
Cresylic acid, 92-99%, straw color, in drums.....gal.	1.10	1.15
Cresylic acid, 95-97%, dark, in drums.....gal.	1.05	1.10
Cresylic acid, 50%, first quality, drums.....gal.	65	75
Dichlorobenzene.....lb.	07	10
Diethylaniline.....lb.	1.45	1.50
Dimethylaniline.....lb.	70	80
Dinitrobenzene.....lb.	30	37
Dinitrochlorobenzene.....lb.	27	32
Dinitronaphthalene.....lb.	42	45
Dinitrophenol.....lb.	40	45
Dinitrotoluene.....lb.	27	30
Dip oil, 25% tar acids, car lots, in drums.....gal.	38	40
Diphenylamine (nominal).....lb.	75	77
H-acid (nominal).....lb.	1.60	1.65
Meta-phenylenediamine.....lb.	1.25	1.30
Monochlorobenzene.....lb.	17	18
Monothylaniline.....lb.	1.75	2.25
Naphthalene crushed, in bbls. (250 lb.).....lb.	09	09
Naphthalene, flake.....lb.	09	09
Naphthalene, balls.....lb.	10	10
Naphthionic acid, crude.....lb.	70	75
Nitrobenzene.....lb.	12	15
Nitro-naphthalene.....lb.	40	50
Nitro-toluene.....lb.	18	25
Ortho-amidophenol.....lb.	3.20	3.75
Ortho-dichlorobenzene.....lb.	15	20
Ortho-nitro-phenol.....lb.	75	80
Ortho-nitro-toluene.....lb.	25	40
Ortho-toluidine.....lb.	30	32
Para-amidophenol, base.....lb.	2.20	2.25
Para-amidophenol, HCl.....lb.	2.10	2.15
Para-dichlorobenzene.....lb.	10	15
Paranitroaniline.....lb.	1.05	1.10

Para-nitrotoluene.....lb.	1.25	1.40
Para-phenylenediamine.....lb.	2.20	2.35
Para-toluidine.....lb.	1.85	2.00
Phthalic anhydride.....lb.	.60	.70
Phenol, U. S. P., drums (dest.), (240 lb.).....lb.	.08	.10
Pyridine.....gal.	2.00	3.50
Resorcinol, technical.....lb.	2.75	3.00
Resorcinol, pure.....lb.	3.75	4.00
Salicylic acid, tech., in bbls. (110 lb.).....lb.	.33	.35
Salicylic acid, U. S. P.....lb.	.37	.40
Salol.....lb.	.85	.95
Solvent naphtha, water-white, in drums, 100 gal. gal.	.30	.35
Solvent naphtha, crude, heavy, in drums, 100 gal. gal.	.19	.22
Sulphanilic acid, crude.....lb.	.32	.35
Tolidine.....lb.	1.40	1.45
Toluidine, mixed.....lb.	.45	.55
Toluene, in tank cars.....gal.	.35	
Toluene, in drums.....gal.	.38	.40
Xylidines, drums, 100 gal.....lb.	.45	.50
Xylene, pure, in drums.....gal.	.45	.50
Xylene, pure, in tank cars.....gal.	.40	.42
Xylene, commercial, in drums, 100 gal.....gal.	.37	.38
Xylene, commercial, in tank cars.....gal.	.30	

Waxes

Prices based on original packages in large quantities.

Beeswax, refined, dark.....lb.	\$0.26	\$0.27
Beeswax, refined, light.....lb.	.28	.35
Beeswax, white pure.....lb.	.35	.40
Carnauba, No. 1 (nominal).....lb.	.80	.90
Carnauba, No. 2, North Country.....lb.	.37	.38
Carnauba, No. 3, North Country.....lb.	.25	.26
Japan.....lb.	.19	.20
Montan, crude.....lb.	.12	.14
Paraffine waxes, crude match wax (white) 105-110 m.p.....lb.	.07	.08
Paraffine waxes, crude, scale 124-126 m.p.....lb.	.07	.07
Paraffine waxes, refined, 118-120 m.p.....lb.	.09	.09
Paraffine waxes, refined, 125 m.p.....lb.	.09	.09
Paraffine waxes, refined, 128-130 m.p.....lb.	.10	.11
Paraffine waxes, refined, 133-135 m.p.....lb.	.13	.14
Paraffine waxes, refined, 135-137 m.p.....lb.	.14	.15
Stearic acid, single pressed.....lb.	.15	.16
Stearic acid, double pressed.....lb.	.16	.16
Stearic acid, triple pressed.....lb.	.16	.17

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr. 0.930-0.940.....gal.	\$1.75
Pine oil, pure, dest. dist.....gal.	1.65
Pine tar oil, ref., sp. gr. 1.025-1.035.....gal.	.48
Pine tar oil, crude, sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla. gal.	.35
Pine tar oil, double ref., sp. gr. 0.965-0.990.....gal.	.85
Pine tar, ref., thin, sp. gr. 1.080-1.060.....gal.	.34
Turpentine, crude, sp. gr. 0.900-0.970.....gal.	.70
Hardwood oil, f.o.b. Mich., sp. gr. 0.960-0.990.....gal.	.35
Pinewood creosote, ref.....gal.	.55

Naval Stores

The following prices are f.o.b. New York, for carload lots.

Rosin B-D, bbl.....280 lb.	\$10.00
Rosin E-L.....280 lb.	10.00
Rosin K-N.....280 lb.	10.00
Rosin W. G. W. W.....280 lb.	10.25
Wood rosin, bbl.....280 lb.	11.00
Spirits of turpentine.....gal.	.80
Wood turpentine, steam dist.....gal.	.79
Wood turpentine, dest. dist.....gal.	.79
Pine tar pitch, bbl.....200 lb.	8.50
Tar, kiln burned, bbl. (500 lb.).....bbl.	15.00
Retort tar, bbl.....500 lb.	15.00
Rosin oil, first run.....gal.	.70
Rosin oil, second run.....gal.	.73
Rosin oil, third run.....gal.	.90

Solvents

73-76 deg., steel bbls. (85 lb.).....gal.	\$0.41
70-72 deg., steel bbls. (85 lb.).....gal.	.39
68-70 deg., steel bbls. (85 lb.).....gal.	.38
V. M. and P. naphtha, steel bbls. (85 lb.).....gal.	.30

Crude Rubber

Para-Upriver fine (nominal).....lb.	\$0.22	\$0.23
Upriver coarse (nominal).....lb.	.14	.15
Upriver cauchó ball (nominal).....lb.	.16	.16
Plantation—First latex crepe.....lb.	.19	
Ribbed smoked sheets.....lb.	.18	
Brown crepe, thin, clean.....lb.	.16	
Amber crepe No. 1.....lb.	.17	

Oils

VEGETABLE

The following prices are f.o.b. New York for carload lots.

Castor oil, No. 3, in bbls.....lb.	\$0.13	\$0.14
Castor oil, AA, in bbls.....lb.	.15	.15
China wood oil, in bbls. (f.o.b. Pac. coast).....lb.	.11	.11
Cocoonut oil, Ceylon grade, in bbls.....lb.	.13	.14
Cocoonut oil, Cochín grade, in bbls (nominal).....lb.	.15	.16
Corn oil, crude, in bbls.....lb.	.09	.10
Cottonseed oil, crude (f.o.b. mill).....lb.	.06	.07
Cottonseed oil, summer yellow.....lb.	.07	.10
Cottonseed oil, winter yellow.....lb.	.11	.12
Linseed oil, raw, car lots (domestic).....gal.	.80	
Linseed oil, raw, tank cars (domestic).....gal.	.75	.77
Linseed oil, boiled, car lots (domestic).....gal.	.82	

Olive oil, commercial.....	gal.	2.75	—	3.00
Palm, Lagos.....	lb.	.08	—	.09
Palm, Niger.....	lb.	.07	—	.08
Peanut oil, crude, tank cars (f.o.b. mill).....	lb.	.08	—	.09
Peanut oil, refined, in bbls.....	lb.	.14	—	.14
Rapeseed oil, refined in bbls.....	gal.	1.15	—	1.20
Rapeseed oil, blown, in bbls.....	gal.	1.25	—	1.35
Soya bean oil (Manchurian), in bbls. N. Y.....	lb.	.09	—	.10
Soya bean oil, tank cars, f.o.b., Pacific coast.....	lb.	.06	—	.07

FISH

Light pressed Menhaden.....	gal.	\$0.65	—	\$0.70
Yellow bleached Menhaden.....	gal.	.67	—	.70
White bleached Menhaden.....	gal.	.72	—	.75
Blown Menhaden.....	gal.	1.05	—	1.10

Miscellaneous Materials

All f. o. b. New York Unless Otherwise Stated

Barytes, ground, white, f.o.b. Kings Creek, S. C.	net ton	\$24.00	—	\$30.00
Barytes, ground, off color, f.o.b. Kings Creek	net ton	22.00	—	26.00
Barytes, crude, 88% @ 94% ba., Kings Creek.....	net ton	10.00	—	12.00
Barytes, floated, f.o.b. St. Louis.....	net ton	26.50	—	28.00
Barytes, crude, first grade, Missouri.....	net ton	10.00	—	12.00
Blanc fixe, dry.....	lb.	.05	—	.05
Blanc fixe, pulp.....	net ton	60.00	—	65.00
Caseine.....	lb.	.14	—	.18
Chalk, domestic, extra light.....	lb.	.05	—	.06
Chalk, domestic, light.....	lb.	.04	—	.05
Chalk, domestic, heavy.....	lb.	.04	—	.05
Chalk, English, extra light.....	lb.	.05	—	.07
Chalk, English, light.....	lb.	.05	—	.06
Chalk, English, dense.....	lb.	.04	—	.05
China clay, (Kaolin) crude, f.o.b. mines, Georgia	net ton	8.00	—	10.00
China clay (Kaolin) washed, f.o.b. Georgia.....	net ton	12.00	—	15.00
China clay (Kaolin) powdered, f.o.b. Georgia.....	net ton	18.00	—	22.00
China clay (Kaolin) crude f.o.b. Virginia points.....	net ton	8.00	—	12.00
China clay (Kaolin) ground, f.o.b. Virginia points.....	net ton	15.00	—	40.00
China clay (Kaolin), imported, lump.....	net ton	25.00	—	35.00
China clay (Kaolin), imported, powdered.....	net ton	30.00	—	35.00
Feldspar, crude, f.o.b. Maryland and North Carolina points.....	gross ton	8.00	—	14.00
Feldspar, crude, f.o.b. Maine.....	net ton	7.50	—	10.00
Feldspar, ground, f.o.b. Maine.....	net ton	21.00	—	23.00
Feldspar, ground, f.o.b. North Carolina.....	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. N. Y. State.....	net ton	17.00	—	21.00
Feldspar, ground, f.o.b. Baltimore.....	net ton	27.00	—	30.00
Fuller's Earth, f.o.b. New York.....	net ton	16.00	—	17.00
Fuller's earth, granular, f.o.b. Fla.....	net ton	25.00	—	28.00
Fuller's earth, powdered, f.o.b. Fla.....	net ton	18.00	—	20.00
Fuller's earth, imported, powdered.....	net ton	35.00	—	40.00
Graphite, crucible, 90% carbon, Ashland, Ala.....	lb.	.07	—	.09
Graphite, crucible, 85% carbon, Ashland, Ala.....	lb.	.11	—	.11
Graphite, higher lubricating grades.....	lb.	.04	—	.50
Pumice stone, imported, lump.....	lb.	.06	—	.07
Pumice stone, domestic, lump.....	lb.	.04	—	.07
Pumice stone, ground.....	lb.	.04	—	.07
Quartz (acid tower) fist to head, f.o.b. Baltimore	net ton	10.00	—	10.00
Quartz (acid tower) 1 1/2 in., f.o.b. Baltimore.....	net ton	14.00	—	14.00
Quartz (acid tower) rice, f.o.b. Baltimore.....	net ton	17.00	—	17.00
Quartz, lump, f.o.b. North Carolina.....	net ton	5.00	—	7.50
Shellac, orange fine.....	lb.	1.00	—	1.05
Shellac, orange superfine.....	lb.	1.05	—	1.10
Shellac, A. C. garnet.....	lb.	.90	—	.95
Shellac, T. N.....	lb.	.85	—	.95
Soapstone.....	ton	15.00	—	25.00
Sodium Chloride.....	long ton	—	—	17.50
Talc, paper-making grades, f.o.b. Vermont.....	ton	12.00	—	22.00
Talc, roofing grades, f.o.b. Vermont.....	ton	9.50	—	15.00
Talc, rubber grades, f.o.b. Vermont.....	ton	12.00	—	18.00
Talc, powdered, Southern, f.o.b. cars.....	ton	12.00	—	15.00
Talc, imported.....	ton	60.00	—	70.00
Talc, California Talcum Powder grade.....	ton	20.00	—	45.00

Refractories

Bauxite brick, 56% Al., f.o.b. Pittsburgh.....	1,000	160	
Chrome brick, f.o.b. Eastern shipping points.....	net ton	100-110	
Chrome cement, 40-45% Cr ₂ O ₃	net ton	55-60	
Chrome cement, 40-45% Cr ₂ O ₃ , sacks, in car lots, f.o.b. Eastern shipping points.....	net ton	60-65	
Fire clay brick, 1st quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works.....	1,000	55-60	
Fire clay brick, 2nd quality, 9-in. shapes, f.o.b. Pennsylvania, Ohio and Kentucky works.....	1,000	45-50	
Magnesite brick, 9-in. straight.....	net ton	110	
Magnesite brick, 9-in. arches, wedges and keys.....	net ton	121	
Magnesite brick, soaps and splits.....	net ton	134	
Silica brick, 9-in. sizes, f.o.b. Chicago district.....	1,000	65-70	
Silica brick, 9-in. sizes, f.o.b. Birmingham district.....	1,000	56-61	
Silica brick, 9-in. sizes, f.o.b. Mt. Union, Pa.....	1,000	55-60	

Ferro-Alloys

All f.o.b. Works

Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.....	net ton	\$200.00	—	\$225.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon, carlots.....	lb.	.17	—	.18
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon, carlots.....	lb.	.16	—	.17
Ferro-manganese, 76-80% Mn, domestic.....	gross ton	140.00	—	145.00
Ferro-manganese, 76-80% Mn, English.....	gross ton	135.00	—	140.00
Spiegelisen, 18-22% Mn.....	gross ton	60.00	—	65.00
Ferro-molybdenum, 50-60% Mo, per lb. of Mo.....	lb.	2.00	—	2.50
Ferro-silicon, 10-15%.....	gross ton	60.00	—	65.00
Ferro-silicon, 50%.....	gross ton	80.00	—	85.00
Ferro-silicon, 75%.....	gross ton	—	—	160.00
Ferro-tungsten, 70-80%, per lb. of contained W.....	lb.	.65	—	.75
Ferro-uranium, 35-50% of U, per lb. of U content.....	lb.	7.00	—	—
Ferro-vanadium, 30-40% per lb. of contained V.....	lb.	6.50	—	7.50

Ores and Semi-finished Products

All f.o.b. New York, Unless Otherwise Stated

Bauxite, 52% Al. content, less than 2% Fe ₂ O ₃ , up to 20% silica, not more than H ₂ O moisture.....	gross ton	\$10.00	—	\$11.00
Chrome ore, Calif. concentrates, 50% min. Cr ₂ O ₃	unit	.60	—	.65
Chrome ore, 50% Cr ₂ O ₃ , f.o.b. Atlantic Seaboard.....	unit	.60	—	.65
Coke, foundry, f.o.b. ovens.....	net ton	9.00	—	10.50
Coke, furnace, f.o.b. ovens.....	net ton	8.00	—	9.00
Coke, petroleum, refinery, Atlantic Seaboard.....	net ton	24.00	—	26.00
Fluor spar, lump, f.o.b. Tonuco, New Mexico.....	net ton	17.00	—	—
Fluor spar, standard, domestic washed gravel Kentucky and Illinois mines.....	net ton	22.50	—	25.00
Ilmenite, 52% TiO ₂ , per lb. ore.....	lb.	.01	—	.01
Manganese Ore, 50% Mn, c.i.f. Atlantic seaport.....	unit	.45	—	.50
Manganese ore, chemical (MnO ₂).....	gross ton	65.00	—	70.00
Molybdenite, 85% MoS ₂ , per lb. of MoS ₂ , N. Y.....	lb.	.55	—	.60
Molybdenite, per unit of ThO ₂ , c.i.f. Atlantic seaport.....	unit	35.00	—	—
Pyrites, Spanish, fines, c.i.f. Atlantic seaport.....	unit	.12	—	—
Pyrites, Spanish, furnace size, c.i.f. Atlantic seaport.....	unit	.17	—	—
Pyrites, domestic, fines, f.o.b. mines, Ga.....	unit	.12	—	.14
Rutile, 95% TiO ₂ per lb. ore.....	lb.	.15	—	—
Tungsten, Scheelite, 60% WO ₃ and over, per unit of WO ₃ (nominal).....	unit	4.25	—	4.50
Tungsten, Wolframite, 60% WO ₃ and over, per unit of WO ₃ , N. Y. C.....	unit	4.00	—	4.25
Uranium Ore (Carnotite) per lb. of U ₃ O ₈	lb.	2.75	—	3.00
Uranium oxide, 96% per lb. contained U ₃ O ₈	lb.	2.75	—	3.00
Vanadium pentoxide, 99%.....	lb.	12.00	—	14.00
Vanadium Ore, per lb. of V ₂ O ₅ contained.....	lb.	1.50	—	—
Zircon, washed, iron free.....	lb.	.05	—	—

Non-Ferrous Metals

New York Markets

	Cents per Lb.
Copper, electrolytic.....	15 00
Aluminum, 98 to 99 per cent.....	22.00 @ 33 00
Antimony, wholesale lots, Chinese and Japanese.....	5 62
Nickel, ordinary (ingot).....	43 00
Nickel, electrolytic.....	45 00
Tin, 5-ton lots.....	36 25
Lead, New York, spot.....	5 75
Lead, E. St. Louis, spot.....	6 25
Zinc, spot, New York.....	7 00
Zinc, spot, E. St. Louis.....	6 75

OTHER METALS

Silver (commercial).....	oz.	.61
Cadmium.....	lb.	\$1.40 @ 1.50
Bismuth (500 lb. lots).....	lb.	2.40
Cobalt.....	lb.	6.00
Magnesium (f.o.b. Niagara Falls).....	lb.	1.75
Platinum.....	oz.	85.00
Iridium.....	oz.	500.00 @ 400.00
Palladium.....	oz.	85.00
Mercury.....	75 lb.	48.00 @ 49.00

FINISHED METAL PRODUCTS

Warehouse Price Cents per Lb.

Copper sheets, hot rolled.....	22.50
Copper bottoms.....	34.00
Copper rods.....	29.00
High brass wire and sheets.....	22.25
High brass rods.....	19.00
Low brass wire and sheets.....	30.50
Low brass rods.....	19.50
Brass tubing.....	36.25
Brass bronze tubing.....	41.50
Seamless copper tubing.....	26.00
Seamless high brass tubing.....	25.00

OLD METALS—The following are the dealers' purchasing prices in cents per pound:

	New York			
	Current	One Year Ago	Cleveland	Chicago
Copper, heavy and crucible.....	12.00	17.00	10.00	11.50
Copper, heavy and wire.....	11.50	16.00	9.50	11.00
Copper, light and bottoms.....	10.00	14.00	9.00	9.50
Lead, heavy.....	4.00	4.75	4.00	4.50
Lead, light.....	3.00	3.75	3.00	3.50
Brass, heavy.....	7.00	10.50	7.00	10.50
Brass, light.....	5.50	7.50	5.00	5.50
No. 1 yellow brass turnings.....	6.50	10.00	5.50	5.50
Zinc.....	4.50	5.00	3.00	4.50

Structural Material

The following base prices per 100 lb. are for structural shapes 3 in. by 1/2 in. and larger, and plates 1/2 in. and heavier, from jobbers' warehouses in the cities named:

	New York		Cleveland		Chicago	
	Current	One Year Ago	Current	One Year Ago	Current	One Year Ago
Structural shapes.....	\$3.80	\$4.15	\$3.58	\$3.37	\$3.58	\$3.47
Soft steel bars.....	3.70	4.15	3.37	3.34	3.48	3.37
Soft steel bar shapes.....	3.70	4.15	3.37	3.48	3.48	3.37
Soft steel bands.....	4.65	5.50	4.07	6.25	—	—
Plate, 1/2 to 1 in. thick.....	4.00	4.15	3.67	3.78	3.78	3.67

Industrial

Financial, Construction and Manufacturers' News

Construction and Operation

Colorado

AULT—The Great Valley Sugar Co., Central Savings Bank Bldg., Denver, has awarded the contract for the construction of a sugar factory to the Schwarz Eng. Co., Mack Bldg., Denver. Estimated cost, \$1,000,000.

LAFAYETTE—The Great Valley Sugar Co., Central Savings Bank Bldg., Denver, has awarded the contract for the construction of a sugar factory to the Schwarz Eng. Co., Mack Bldg., Denver. Estimated cost, \$1,000,000.

PLEASANT VALLEY (Noel P. O.)—The Great Valley Sugar Co., Central Savings Bank Bldg., Denver, has awarded the contract for the construction of a sugar factory to the Schwarz Eng. Co., Mack Bldg., Denver.

Idaho

WEISER—The city plans an election Jan. 4 to vote on \$150,000 bonds to improve water-works, including a filtration plant. Burns & McDonnell, 402 Interstate Bldg., Kansas City, Mo., consulting engineers.

Illinois

CENTRALIA—The American Rubber Co., 1526 South Wabash St., will soon award the contract for the construction of a 2-story, 60x400-ft. rubber factory. Estimated cost, \$100,000. The Consulting Co., 2801 Union Central Bldg., Cincinnati, archt.

SPRINGFIELD—The city is having plans prepared for the construction of an iron removal and softening plant to have a 15,000,000-gal. capacity. Burns & McDonnell, 402 Interstate Bldg., Kansas City, Mo., consult. engrs.

Indiana

KENDALLVILLE—The Noble Tire & Rubber Co. will receive bids after Jan. 1 for the construction of a 2-story, 50x200-ft. rubber factory. Estimated cost, \$75,000. A. M. Strauss, 207 Bank Bldg., Ft. Wayne, archt.

TERRE HAUTE—The Union Hospital, 7th and 8th Aves., plans to build a 6-story, 44x200-ft. hospital. Laboratory equipment will be installed in same. Estimated cost, \$300,000. Johnson, Miller & Miller, 105 South 7th St., archts.

Iowa

DES MOINES—The Salvation Army, S. E., 6th St. and Indianola Rd., has had plans prepared for the construction of a 2-story, 54x136-ft. maternity hospital. A chemical laboratory will be installed in same. Estimated cost, \$150,000. Sawyer & Watrous, 401 Hippee Bldg., archts.

POCAHONTAS—The Bd. Educ. will receive bids until Dec. 30 for the construction of a 2-story, 56x110-ft. high school. A chemical laboratory will be installed in same. Estimated cost, \$150,000. W. E. Hulse & Co., 309 Securities Bldg., Des Moines, archt.

TRIPOLI—The Bd. Educ. will receive bids about Feb. 15 for the construction of a 3-story, 64x100-ft. grade and high school. A chemical laboratory will be installed in same. Estimated cost, \$200,000. Keffner & Jones, 204 Masonic Temple, Des Moines, Iowa, archts.

WILLIAMS—The Currie Eng. Co., Webster City, has awarded the contract for the construction of a sewage disposal plant, to W. E. Welden, Iowa Falls. Estimated cost, \$17,369.

Kansas

BAXTER SPRINGS—The General Amer. Oil Co., 604 New First Natl. Bank Bldg., Tulsa, Okla., will build a 1-story oil refinery in the southeastern section of the town. Estimated cost, \$100,000.

Minnesota

WAYZATA—The Bd. Educ. has awarded the contract for the construction of a 1-story, 200x200-ft. grade and high school, to the Madsen Constr. Co., 843 Builders

Exch. Bldg., Minneapolis. A chemical laboratory will be installed in same. Estimated cost, \$134,915.

New Jersey

CAMDEN—J. B. Van Selver Co., Market St. Ferry, has awarded the contract for the construction of a 1-story, 30x70-ft. kiln building, to P. Haibach, 26th and Thompson Sts., Philadelphia, Pa.

NEW BRUNSWICK—The State of New Jersey is having plans prepared for the construction of a 2-story, 50x80-ft. ceramic building. Estimated cost, \$100,000. F. H. Bent, 142 West State St., Trenton, archt.

RIDGEFIELD—The Continental Paper Box Co., 122 Washington St., Brooklyn, N. Y., will soon award the contract for the construction of a 2-story, 100x500-ft. factory on Grand and Hall Sts. Estimated cost, \$250,000. W. B. Wells, Inc., 1181 Myrtle Ave., Brooklyn Ave., Brooklyn, N. Y., archt. and engr.

North Dakota

UNDERWOOD—The Bd. Educ. will soon receive bids for the construction of a 2-story high school. A chemical laboratory will be installed in same. Estimated cost, \$100,000. W. D. Gillespie, 644 Bway, Fargo, archt.

Ohio

CLEVELAND—The Crossley Rubber Co., 2170 East 18th St., has awarded the contract for the construction of a 1-story, 30x40-ft. factory, to G. E. Peterson, 15924 Euclid Ave. Estimated cost, \$10,000.

CLEVELAND—The Premier Refining Co., 1187 West 11th St., plans to alter the 2-story factory on Howard Ave. Estimated cost, \$35,000. Service Constr. Co., 6110 Euclid Ave., archt.

COLUMBUS—Ohio State University plans to construct an experimental laboratory building. Estimated cost, \$50,000. J. N. Bradford, archt.

Texas

DALLAS—The Bd. Educ., Municipal Bldg., has awarded the contract for the construction of a 2-story high school on Haskell and McKinney Sts., to the Amer. Constr. Co., 411 Gulf Bldg., Houston. A chemical laboratory and equipment will be installed in same. Estimated cost, \$765,000.

West Virginia

CHARLESTON—The city plans to build an electric chlorine plant and install meters in same.

Wisconsin

JANESVILLE—The Bd. Educ. is having plans prepared for the superstructure of a 3-story, 180x200-ft. high school. A chemical laboratory will be installed in same. Estimated cost, \$500,000. VanRyn & DeGellike, Caswell Bldg., Milwaukee, archts.

NEENAH—The Neenah Paper Co. has awarded the contract for the construction of a 1-story, 60x130-ft. water filter plant, to C. R. Meyer & Sons Co., 50 State St., Oshkosh. Filters will be installed in same.

TWO RIVERS—The Bd. Educ. will receive bids about Jan. 1 for the construction of a 3-story, 96x110-ft. high school. A chemical laboratory will be installed in same. Estimated cost, \$400,000. J. D. Chubb, 109 North Dearborn St., Chicago, Ill., archt.

British Columbia

PRINCE GEORGE—The Eastern Syndicate will receive bids in January for the construction of a pulp and paper plant, etc. Estimated cost, \$6,000,000.

VANCOUVER—The Coast Range Steel Co., 419 Metropolitan Bldg., recently incorporated with \$15,000,000 capital stock, plans to build a large iron and steel works near here.

Ontario

WALLACEBURG—The Wallaceburg Glass Co., Ltd., plans to expend \$50,000 on its plant. Equipment will be installed in same.

WELLAND—The Cross Mfg. Co., Sydney, N. S., plans to build a fertilizer plant here. Estimated cost, \$250,000.

Coming Meetings and Events

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE will hold its 1920 meeting Dec. 27, 1920, to Jan. 1, 1921, at Chicago, Ill.

AMERICAN CERAMIC SOCIETY will hold its annual meeting the week of Feb. 21, 1921, at Columbus, Ohio, with headquarters at the Deschler Hotel.

AMERICAN CHEMICAL SOCIETY will hold its sixty-first meeting at Rochester, N. Y., April 26 to 29, 1921.

AMERICAN ELECTROCHEMICAL SOCIETY will hold its spring meeting at Atlantic City April 21 to 23 inclusive. Headquarters will be at the Hotel Chalfonte.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its spring meeting Feb. 14 to 17 in New York City.

AMERICAN PHYSICAL SOCIETY will hold its annual meeting, beginning Dec. 28, at Chicago, it being the occasion of the special quadrennial meeting of the American Association for the Advancement of Science and the Affiliated Societies.

COMMON BRICK MANUFACTURERS' ASSOCIATION OF AMERICA will hold its annual meeting at the Hotel Pennsylvania, New York City, Jan. 31 to Feb. 4.

NEW JERSEY CHEMICAL SOCIETY holds a meeting at the Statler Restaurant, Newark, N. J., the second Monday of every month.

SOCIETY OF CHEMICAL INDUSTRY holds its Perkin Medal Award Meeting at Rumford Hall, Chemists' Club, New York, on Jan. 14, 1921.

The following chemical societies will meet at Rumford Hall, Chemists' Club, New York City, as follows: Jan. 7, American Chemical Society; Jan. 14, Society of Chemical Industry, Perkin Medal award; Feb. 11, American Electrochemical Society, joint meeting with Society of Chemical Industry, American Chemical Society and Société de Chimie Industrielle; March 11, American Chemical Society, Nichols Medal award; March 25, Society of Chemical Industry, joint meeting with American Electrochemical Society, Société de Chimie Industrielle and American Chemical Society; May 6, American Chemical Society; May 13, Société de Chimie Industrielle, joint meeting with American Chemical Society, Society of Chemical Industry and American Electrochemical Society; May 20, Society of Chemical Industry; June 10, American Chemical Society.

Industrial Notes

W. S. QUIGLEY, president Quigley Furnace Specialties Co., New York City, has just returned from Europe after an extensive trip made in connection with large installations of the Quigley Powdered Coal System in Italy and Belgium.

THE MISSOURI PORTLAND CEMENT Co. has established offices at the Union and Planters Bank Bldg., Memphis, Tenn. The company is installing a large sand and gravel producing plant in that city to operate in conjunction with the present plant in South Memphis.

THE ALEMITE LUBRICATOR Co. of Chicago, Ill., has established district offices at 47 Monroe Ave., Memphis, Tenn. George Hyatt is local manager of the new office.

THE GENERAL MANUFACTURING Co., with a capital of \$150,000, has been established at 390 South Front St., Memphis, Tenn., and will manufacture insecticides and perfumes.

THE MEMPHIS SILICA Co. has acquired a 20-acre silica deposit at Riverton Junction, Ala., and is now arranging for trackage to serve the mines. The executive sales headquarters of the company will be located in Memphis and the product will be distributed for use in manufacture of paint, glass, pottery, cement, cleansers, etc., N. E. Goddard is president, W. J. Whitford vice-president, and J. B. Druschel secretary-treasurer of the new company.

THE NORTHERN REFRACTORIES Co. has been organized with main offices at Ridgeway, Pa., Ives L. Harvey, president, M. T. Shanley, secretary. It is opening up deposits of high-grade clay on its property at Hutchins, Pa., and will put on the market a high-grade flint and ground clay.

THE AMERICAN DRESSLER TUNNEL KILNS, Inc., has moved its executive, engineering and thermal offices to 1740 East Twelfth St., Cleveland, O.

ENGLE TILE & FUEL Co. of Newton, Ill., will install a direct heat-radiating drier. This plant specializes on drain tile.